ECOLOGICAL STUDIES RELATED TO DISTRIBUTION AND ASSESSMENT OF INJURY LEVEL OF APHID *LAPAPHIS ERYSIMI* K[illegible] INFESTING *BRASSICA CAMPESTRIS*"

A
THESIS
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ZOOLOGY
BY



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UNDER THE SUPERVISION OF
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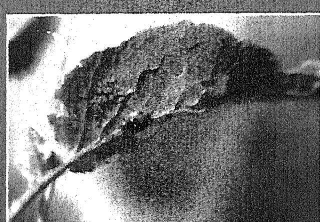

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CERTIFICATE

This is to certify that the present thesis entitled, "Ecological studies related to distribution and assessment of injury level of aphid, *Lipaphis* ERYSIMI K. infesting *Brassica campestris*" submitted by Sri Anil Kumar Saunakiya embodies the findings of his original research work carried out under my supervision and it fulfills all the conditions prescribed by Bundelkhand University, Jhansi (U.P.) for the award of Ph.D. Degree. He has worked more than 250 working days in the Department of Zoology, D.V. (P.G.) College, Orai, Jalaun (U.P.) to complete this investigation.

Prabhat Kumar

Dated: 4. 6. 08

Dr. Prabhat Kumar

(Supervisor)

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4.6.08

Dated:

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INTRODUCTION

CHAPTER - ONE

INTRODUCTION

Oil seeds constitute a major source of dietary requirements of lipids for human health.Upto mid seventies; the emphasis was to increase the production of cereals. But after the success of "Green revolution", major attention has now been shifted to increase the production of oil seeds. The planners realized that in order to meet the domestic requirements of oilseeds, the country has to import oil and oilseed worth thousand crores every year, which drains out valuable foreign exchange. In this context that "Technology mission" on oilseed was launched in 1986 to increase the production of oilseeds in the country thus, gradually phase out the imports.

Among the oilseeds, the rapeseed – mustard comprises the most important edible oilseed, cultivated mainly for its seeds owing to edible quality of the oil. Beside, the crop is also used as `Saag` as its leafy stage for human consumption, being a rich source of vitamin A and iron. It is also used as green fodder for the cattle. Its seed cake is very nutritive feed for the live – stock.

Among the oil seed growing countries, India ranks second after U.S.A having an area of 25.26 million hectares under oil seeds with the production of 21.42 million tonnes and productivity 848 kg/ha, which share about 18.46 per cent of the world production for oil seeds. At national level, rapeseed –mustard covered 6.23 million hectare area and produced 5.88 million tonnes with the productivity level of 944 kg/ha. Uttar Pradesh stands second after Rajasthan in area as well as production of rapeseed mustard having 1.164 million hectare and 1.174 million tonnes respectively. Rapeseed mustard is a major oilseed crop in U.P, which covered 67.79 % area with 81.52 % production of the total 1.716 million hectare area and 1.44 million tonnes production at state level. Agra, Aligarh ,Etawah , Farrukhabad ,Ferozabad , Fatehpur ,Kaushambi , Mathura , Allahabad , Bulandshahar , Badaun , Kheri and Kanpur are major rapeseed mustard producing districts on the map of Uttar Pradesh. The productivity of this crop in U.P is 1009 Kg/ha against 944 Kg/ha of the country (Anon., 1995). Although the average productivity of this crop at state level is better than the national level but far below than the yield potential of improved varieties of rapeseed mustard.

A number of new genotypes and varieties with fairly high average yield upto 20 g / ha have been recently developed. However, such high yield potentials are never realized due to cultivation of the crop mostly under rain fed conditions with poor input application and many biotic and abiotic constraints.

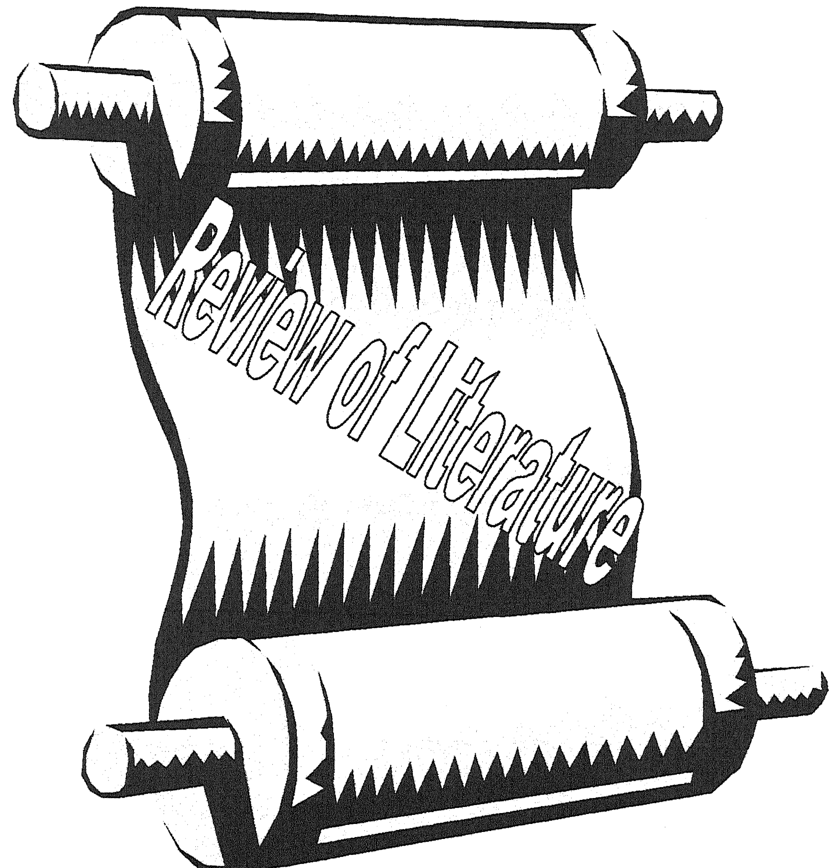
Among the various constraints in their productivity, the infestation of insect pests is one of the most important limiting factor for its such low yield. Mustard crop is found to be harbour as many as thirty-eight insect pest during its different growth stages ([illegible]). During early stages ,the crop is severly attacked by painted bug, *Bagrada cruciferarum* Kirk. and sawfly ,*Athalia proxima* Klug, while in the latter stages , the crop is infested by aphid ,*Lipaphis erysimi* Kaltenbach and pea leaf minor,*phytomyza atricornis* Meig. But mustard aphid , *L ._erysimi* has a prime importance infesting at flowering stage and causes up to 91.3 per cent yield loss in different parts of the country ([illegible]). Its losses to mustard crop are 34.68 per cent at Kanpur, 59.49 per cent at Pant Nager, 72.61 per cent at Ludhiana ,29.43 per cent at Navgaon ([illegible]) and may be as high as 27 – 96 per cent ([illegible]).

The incidence and rate of increase of aphids is so fast that by the time incidence is felt and appropriate control measures are taken, their population reaches alarming proportions on the crop. Till recently, use of insecticides was considered most effective control measure to solve the pest problem. Many workers have recommended chemical control measures against the aphids in order to save the crop from terrible yield losses (Phadke , 1980 ; Hazarika and Saharia ,1981 ; Prasad et. al. ,1983 ; Budhraj et. al. , 1983 ;Kalra and Gupta , 1986 ; Singh et. al. 1986 ;Ram kishore and Phadke ,1988 ; Kotwal et. al. 1990 ; Upadhyay and Agrawal ,1993 ; and Kumar et. al. 1996).

The indiscriminate use of insecticides results unnecessary expenditure and also creates many secondary problems. This urgently calls for managing insect population as per the principles of integrated pest management. Thus, IPM is the only way out to over come the different problems for eco – friendly farming to mustard, which will include not only the chemical control but an array of other practices like cultural measures and biological control. These practices need to be blended for efficient and economic management strategies for *L. erysimi.* This will certainly provide sustainable expansion to the productivity of this crop. Therefore, economic injury level concept has become one of the most influential element in pest management decision making.

Keeping the above view in mind, a study is planned to investigate the following aspects:

1. To study the population dynamics of *L. erysimi* in relation to environmental factors.
2. To study the rate of multiplication of aphid infesting the crop.
3. To determine the response of different varieties of mustard to *L. erysimi* .
4. To study the spatial distributation of *L. erysimi* and its natural enemies.
5. To assess the economic injury level of *L. erysimi.*
6. To assess the economic threshold of *L. erysimi* on different varieties of mustard.
7. To develop forecast model for the management of *L. erysimi.*


Review of Literature

CHAPTER - TWO

REVIEW OF LITERATURE

The relevant literature on various aspects of present investigation on mustard aphid, *Lipaphis erysimi* have been critically reviewed and being presented in the following chronological order under appropriate heads.

(I) Insect : Its Population Dynamics And Varietal Response.

As early as 1909, Lefroy reported *L. erysimi* infesting mustard crop in different states of India and found that the pest first appear during November-December and makes colonies and damage the crop by draining the sap from the plant stem. There is development of shooty moulds on honey dew secreted by this insect, which finally affect the yield of the crop adversely.

Narayanan (1958) observed that this aphid generally appears in November and causes severe damage to the various cruciferous crops upto April. This number goes on decreasing as the temperature rises and the summer approaches, with the development of a generation of winged adults. The winged aphids are often observed flying about in February and March.

Singh and Sandhu (1958) reported that the mustard aphid makes its first appearance in November and remains active upto April in Punjab. Thereafter the population decreases considerably with the production of a generation of winged adults and their colonies develop on the plants growing

in cool and moist places. The multiplication of pest is favoured by moist and cloudy weather.

Pradhan et. al. (1960) stated that the mustard crop may be severely infested by this pest in the later stages also. In his later publication Pradhan ([illegible]) reported that aphid make their appearance at the on set of winter and continue to breed parthenogenatically till the end of spring, when the winged individuals are produced and their large scale dispersal take place.

Atwal et. al. (1971) noticed that the fluctuation in population growth was brought about mainly by high temperature and maturing food. The aphid population decreases immediately after every rainfall but increases within a week during spring.

Srivastava et. al. (1972) observed that the incidence of mustard aphid starts from November and continues till the end of February. The peak period of its attack was January - February.

Srivastava and Srivastava (1972) observed maximum incidence of the pest, when temperature ranged from 17-18^{0}C and relative humidity 61-83 per cent.

Roy (1975) studied the population dynamics of mustard aphid and observed that the aphid population was independent of the effect of temperature and humidity. Rain had, however, profound effect on its population and was one of the most consistent factor in population reduction of *L. erysimi.*

Prasad and Phadke (1980) studied the population of aphids was high on yellow *sarson* and *toria* varieties of *Brassica campestris,* lower on *rai, B. juncea* and lowest on 'Banarsi Rai', *B. nigra*.

Phadke (1982) studied the aphid on the leaf portion under a microcage during the period from January - March. The net reproductive rate on the four varieties was found to be : YS-Pb-24, 114-377; BSH-1, 94.250; T-9, 199.377 and Pusa bold 86.121. The true value of intrinsic rate of increase (r m) was 0.2018, 0.1552, 0.2062 and 0.1648 females per female per day on these respective varieties. The varieties YS-Pb-24 and T-9 were found more favourable for aphid multiplication than the other two varieties.

Bakhetia and Sindhu (1983) noticed a sharp decline in pest population due to rainfall, if it continues for 4-5 days. They also noticed that after the continuous rainfall even for three days aphid did not build up to higher proportion in the subsequent weeks.

Chandra and Kushwaha (1986) reported the role of key abiotic factor regulating the field population of two aphid species viz., mustard aphid *(L. erysimi)* and green peach aphid *M. persicae* on mustard, cauliflower and cabbage crops. The incidence of *L. erysimi* was observed throughout the year on different host plants i.e from May to July on *asgandha (Withania somnifera),* August to March on cauliflower (*B. oleracea* Var. *botrytis)* September to March on cabbage (*B. oleracea* Var. *capitata*), October to March on mustard (*B. juncea*) and March to April on radish (*Raphanus sativus).* In case of cabbage and cauliflower the population initiated a week after transplantation and in mustard following four to six weeks after sowing. In case of these crops, population density of *M. persicae* was relatively lower and more erratic particularly in case of vegetable crops as compared to that

of *L. erysimi*. The most vulnerable period of high population of two species on the three crops varied from second week of January to last week of February. The population of *L. erysimi* and *M. persicae* in initial rising phase and ultimate falling phase were generally negatively correlated with temperature and positively correlated with humidity.

Mathur and Singh (1988a) observed that the abundance of *L.*erysimi had a definite pattern of distribution on the plant as its number was much higher on upper and lower leaves than the middle ones.It`s population was observed in the month of January and it was independent on the effect of temperature and the rainfall had shown the detrimental effect.

Mathur and Singh (1988a) reported that the population was noticed Ist on *B. juncea* which was in the flowering stage during January and a week later on *B. campestris* and its intensity was more on *B. campestris* in later stage. The infestation of aphids usually appears on newer leaves, but the red form of *M. persicae* behaved in somewhat different manner, its incidence was first noticed in bunches of flower buds and small colonies were formed on inflorescence. The maximum attack of *L. erysimi* was to the extent of 4.50 and 4.37 on *B. juncea* and *B. campestris,* respectively, in the middle of March, while *M. persicae* had 2.17 and 1.23 indices in 2nd and 3rd week of February on these crops. The maximum temperature above 15^{0}C with relative humidity below 75 per cent, increase in wind velocity more than 3 Km. per hour and rate of evaporation 5 mm per day, had their combined effect in a sudden fall of aphid population as prevailed during third week of March.

Sachan and Sharma (1986) studied the antibiosis response of various mustard varieties on growth and development of *L. erysimi* at

27±1^{0}C with 60 to 80 per cent relative humidity in BOD incubator. The nymphal duration, number of moults, nymphal survival, pre and post reproductive periods did not differ significantly on 11 mustard varieties. Reproductive period differed significantly being maximum on RH 88.17 (8.44 days) and minimum on RH 78.46 (5.78 days) followed by RLM-198. The fecundity rate was highest on PR 18 (6.03 nymph/female/day) and lowest on RLM 198 and RH 7846 (4.48 nymph/female/day).

Singh and Singh (1986) reported that the maximum population of mustard aphid 172 aphid/plant on BSH-1 during first week of January and 88 aphid/plant on BC-2, 96 aphids /plant on T-6342, 58 aphids / plant on *B. nigra* during 3rd week of February and 152 aphids /plant on Gulliver during the end of February. It clearly shows that BSH-1 and Gulliver varieties were more preferred by mustard aphid as compared to other varieties. Mustard aphid appeared early on BSH-1 because the variety came into flowering 50 days after sowing as compared to 76, 83, 113 and 132 days for the varieties, T-6342, *B. nigra* BC-2 and Gulliver, respectively. Average temperature maximum of 25.31^{0}C and minimum of 5.15^{0}C with RH 88 per cent morning, 28 per cent evening proved most conductive for the development of mustard aphid irrespective of varieties. The average temperature (maximum) beyond 30^{0}C, action of lady bird beetle, *Coccinela septempunctata* Linn. and maturity of the crops proved detrimental for the development of mustard aphid.

Tripathi *et. al.* (1986) found that nymphal period, number of moults and nymphal survival of *L. erysimi* did not differ significantly on different parts of *B. campestris* Var. *toria.* Nymphal survival ranged from 90.03 per cent on the leaf stage plant to 93.24 per cent on leaf bud. Similarly, pre

reproductive period also did not differ on various host parts being minimum 0.45 days on hard leaf and maximum 1.1 days on stalk. Pterate adult formation was maximum (46.66 per cent) on hard leaf . Pod was most suitable parts, followed by stalk and tender leaf to the development of mustard. However, hard leaves were most unsuitable.

Prasad (1986) reported the aphid infestation indices were minimum 0.2-0.3 in EC 114317, EC 114116, EC 114337 against 2.6 to 3.2 in Pusa Kalyani (check line). All 71 germplasm have shown less than 0.9 aphid infestation which is the mean value of 159 indigenous and 17 exotic gemrplasm of *B. juncea.*

Prasad and Phadke (1986) noticed that at the beginning of the season the number of aphid per plant varied from 0.41 on Varuna to 0.75 on ISN-17 and subsequently the number increased on all types of *B. campestris, B. alba, B. napus,* except *B. carinata.* The rate of increase was high on all varieties of *B. campestris* and Indian mustard. Infestation peaked on 16 February on Indian mustard with 83.0 aphids/shoot on Varuna and 188.0 aphids/shoot on RLM-198. Population span on varieties of *B. napus* peaked on 27 February, ranging from 102.20 to 161.30 aphids / shoot.

Vir and Henry (1987) reported that variety T-59 and Durgamani were the most resistant to attack of *L. erysimi* on mustard.

Kalra (1987) obtained a highly positive correlation between aphid population and important cultural practices i.e. date of sowing (early, normal and late), nitrogen level (0.30 and 60 kg. N/ha), number of irrigation (0, 1 and 2) and row spacing (30, 45 and 60 cm) on *B. juncea.* The contribution of

these practices was determined to be more than 80 per cent on the basis of coefficient of determination (R^2) in regulating the aphid population.

Pal and Ghosh (1987) found that *L. erysimi* occurred almost throughout the crop season of *B. juncea,* with a peak in incidence during late December and January. Its indices gradually increased with varying date of sowings from 26 September, October 11, 23 and November 12. Activity of Coccinellid predators of aphid was more during early crop season in November-December.

Chandra and Kushwaha (1987) studied that number of *L. erysimi* and *M. persicae* on mustard were highest from mid January to late February. The parasite *Diaretus rapae* was major parasitoid of both species, attacking upto 93 per cent of *L. erysimi* and 79.8 per cent of *M. persicae. Aphidius* spp. was a minor parasitoid which was active from August to December, parasitizing upto 22.4% of *M. persicae* during the 3rd week of November.

Jaglan et al. (1988) observed the maximum population of *L. erysimi* infesting mustard cv. Prakash from the end of February to end of March. Temperature and humidity did not influence aphid population but rainfall caused a significant and sudden population reduction.

Kalra (1988) found three Coccinellid - *Coccinella septempunctata, Menochilus sexmaculatus* and *Hippodamia variegata;* two chrysopids - *Chrysoperla carnea* and *Anisochrysa boninensis;* the syrphid - *Episyrphus balteatus* and the Chamaemyiid - *Leucopis* spp., associated with aphid colonies. Among them *Leucopis* spp., *Coccinella septempunctata* and *E. balteatus* were in significant numbers.

Malik (1988) could not get any resistance in *B. Juncea, B. napus, B. nigra* and 3 varieities of *B. campestris* against *L. erysimi* though there was some varietal susceptibility.

Singh and Yadav (1988) reported that *B. juncea* strains are more tolerant to aphid infestation than *B. campestris* strains.

Rai et. al. (1988) reported that most of the mustard cultivars were found free from attack by *L. erysimi* but white glossy flower harboured the fewest aphids.

Bakhetia and Ghorband (1989) observed both aphid population per plant and percentage of mustard plants infested with *L. erysimi* were shown to be equally reliable for estimating the incidence of aphid on mustard crop.

Chiman and Kumar (1989) reported that optimum temperature for rapid multiplication of parasitoid *Diaretiella rapae* on *L. erysimi* was 24-28^{0}C, and the adult parasitoid tolerated temperature of 18-30^{0}C, relative humidities of 50-70% were suitable and development was fastest when it is associated with 26-28^{0}C.

Ghosh and Chaudhry (1989) raised 44 generations in one year and the duration of the nymphal stage varied from 5 to 7 days. Adult life span varied from 7-35 days with in a generation, and 36-158 young ones were laid by apterous viviparous females.

Prasad and Phadke (1989) reported that early flowering cultivars were more heavily infested than later ones.

Sinha *et. al.* (1989) reported that the temperature maximum (21.7-23.5^{0}C) and minimum (7.2-9.4^{0}C) in January - February appeared to be

highly conductive to population build up of aphid. Minimum humidity (55.7-69.4%) in January - February favoured population build up. While high humidity had little effect. Activity of the pest ceased at 50.09% humidity and below. Frequent rains during the phase of population increase adversely affected the aphid population.

Singh et. al. (1990) studied that alates of *L. erysimi* began to appear in the 3rd week of January with increase in temperature, and maturity of the crop. High wind speed helped in migration of winged aphids. Maximum alate production occurred in the last week of February and Ist week of March, when the average minimum and maximum temperatures were 9.6 and 25.6^{0}C, respectively. Water stress of the host plants and increasing photoperiod enhanced alate production.

Sinha et. al. (1990) reported that the aphid appeared in the third week of December, increased in January/February and reached at peak number in mid February. The temperature of environment was important in aphid multiplication. Frequent rain kept the population density low.

Zhao and Wang (1990) obtained negative correlation between the preoviposition period and temperature. The duration of development of various instars decreased with an increase in temperature. The most suitable temperature for development was 16-23^{0}C.

Kumar *et. al.* (1990) reported that the combining ability was studied in 5 resistant and 4 susceptible indian mustard parents and their 36 F_1 hybrids for resistance parameters (aphid colony size and percentage plant infestation) against *L. erysimi* under adequate yield infestation under field condition in Haryana, India. The general and specific combining ability

variances were significant for both parameters. Parents T-6342 and RLM 198 were good combiners with desirable performance for both resistance parameters. The good posses RH 30 x RLM 198 and RH 30 x T 6342 were good for developing aphid tolerant genotypes.

Titayavan and Altieri (1990) noticed that direct application of an allyl isothiocyanate emulsion at rate of 0.25 ml per broccolii plant consistently gave higher aphid parasitization rate and/or number of parasitoids per plant than those observed on plants treated with 0.25 ml of water or with 0.25 ml of wild mustard (*Brassica* spp.) extract. These results suggest the existence of hydomone mediated interaction between the species the parasitoid *D. rapae on Bravicoryne brassicae* indicating potential avenues to field parasitization rates through manipulation of the chemical environment of cropping systems.

Weibull and Melin (1990) observed that *B. juncea, B. napus.*and *B. campestris,* differed in their host suitability for the aphid *B. erysimi,* for their phloem sap content of free amino acids by analysis of excised stylets from feeding aphids. The total free amino acid concentration ranged low mean of 1176.0 μ mhol /mg fresh weight (*B. campestris* Var. yellow *Sarson*) and to high mean of 2869.5 mhol/mg fresh weight (*B. campestris* Var. brown *Sarson*). All plants had very little glycine, gama-Amino-butyric acid (GABA), methionine and typtophan in their sap. The amino acid pattern was closely resembled that of cereals. The slow population growth of aphid on *B. juncea* as compared to that on *B. campestris* was thought to be due to other nutritional factors.

Rohilla *et.al.* (1990) screened eighteen varieties in the field for size of aphid population and found that percentage of shoot infestation was

positively and significantly correlated with number of aphid/central shoot. The late flowering varieties RL 18 and RLM -198 were resistant and RLM 14, Vardan, RH 819 and RH 7859 were tolerant.

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Singh et.al. (1991) studied the segregation analysis in the parental, F_1, F_2 and back cross generations from 2 crosses in *B. puncea* line RC 199 and the wild type varieties RH-30 and Varuna indicated that the petalous character is dominant over apetalous ratio, indicating the involvement of 2 duplicate genes, this was supported by 3:1 segregation ratio obtained by back cross progeny showed tolerance of mustard aphid *(L. erysimi)*, hence the use of apetalous material in breeding for tolerance of this pest is recommended.

Talpur *et. al.* (1991) reported from Pakistan that *B. campestris* Cv. P-63 and P-7 and *B, juncea* (Indian mustard) Cv. S-9 were the most resistant cultivars to aphid *L. erysimi.*

Yadav et al. (1991) reported that result from a 6 x 6 crosses involving 3 aphid resistant and 3 aphid susceptible *B. juncea* parents revealed that 2 crosses (T-6342x RH 7846 and granti x T-6342) showed desirable SCA effect for resistance T-6342 and RH 7846 were the best general combiners for resistance.

Kher and Rataul (1991) studied the settling behaviour of *L. erysimi* on 7 strains of *B., campestris,* 7 strains of *B. juncea* (Indian mustard) and 5 strains of *B. napus* (Sarson), in free choice experiments with all plant species present at the cotyledon stage. *B. campestris* was preferred, while *B. napus* was significantly less preferred than others. At the Z leaf stage, *sarson* was again the least preferred and *B. campestris* BSH-1 was the most susceptible of the plants tested followed by *B. campestris*-span and YSPb-24, *sarson* BSL-1512 was the most resistant followed by GSL-1501 and GSL-1.

Sachan and Sachan (1991) found that in *B. juncea* susceptibility to the aphid, *L. erysimi* is due to higher contents of protein, sugar and oil followed by those shows moderate susceptibility were having significantly higher phenol contents. A significantly negative correlation was found between aphid population and phenol content.

Kakkar and Sharma (1991) observed that population counts of insect pollinators on open bloom revealed that *Aphis cerena indica* accounted for 40 per cent of total insect visitors. Honeybee pollinated plants showed about 3 folds, increase in yield over control. Further more, the weight and per cent germination of the seed also improved significantly.

Khurana and Bhatnagar (1991) reported that a sample of 10 central stalks (10 cm long) from randomly selected mustard plants was the optimum sample size for estimating aphid population.

Bhadauria et al. (1992) studied that the early sown crop (15 October) was less infested by aphid and gave the highest yield as the aphid appears on this crop after 74-76 days of sowing and increase in population was observed only up to 86-94 days after sowing. The regression equation indicated that every ten days delay in sowing resulted in an increase of 35.8 aphids/5 cm apical twigs and reduction of 93.1 kg. in grain yield. On an increase of one aphid/5 cm twig, there was a reduction of 2.6 kg/ha in grain yield.

Bishnoi *et. al.* (1992) reported that Indian mustard *B. juncea* after clearance of western disturbance and a sharp rise in air temperature by 6-10^{o}C, the population build up in aphids may further intensify on these crops. The temperature of 10-13.5^{o}C and relative humidity of 72-85 per cent proved optimum.

Raj *et.al.* (1992) showed that in general varieties in the *B. juncea*, *B. carinata* and the *B.napus* group were more resistant to *L. erysimi* than varieties in the *B. campestris* group.

Nain and Bisht (1993) reported that the honeybee visit flowers of mustard and rapeseed for pollen and nectar and provide 5 to 19 fold increase in yield of rapeseed.

Rana *et. al.* (1993) reported that the aphid *L. erysimi* made its appearance towards the end of December or Ist week of January on rapeseed and mustard. An average temperature of 14.12^{o}C coupled with 65

per cent RH proved most conductive for the development of this pest. The contribution of abiotic factors viz., temperature, humidity and rainfall, collectively accounted for 67.51 and 52.45 per cent to the population dynamics of *L. erysimi*. Temperature (minimum), RH (evening) and rainfall exhibited deleterious impact on the population of mustard aphid as they had significantly negative correlation with its population.

Agarwala and Bhattacharya (1994) determined the relationship between the aerial density of immigrant alate of *L. erysimi* on mustard.

Basavaraju et al. (1994) observed longer post reproductive period and longevity of *L. erysimi* derived from alate parents (7.75-5.37 and 30-35 days, respectively) and the total number of nymphs was greater ranging from 124-155 as compared to aphid derived from apterous parents. The reproductive and longevity periods of alate aphids were 0.37-1.12 and 17.75 -18.12 days, respectively. The total number of aphids laid by alate aphids was also low, ranging from 39.71.

Goel and Singh (1994) reported that the value of intrinsic rate of natural increase (rm) and finite rate of increase (λ) were 0.1035, 0.096, 0.023 and 1.109, 1.01, 1.023 females / female/day. The doubling time (DT) was higher in case of alates during March (13.088 days) than in apterae during January (6.697 days) and February (7.220 days). On the population reaching a stable age distribution, the nymphal population estimated was 84.36, 93.87 and 88.67 in January, February and March, respectively. The life expectancy of newly born nymph of *L. erysimi* declines monotonically with advancing age in these months.

Rizvi et al. (1994) reported that fourth instars larvae of *Coccinella septempunctata* were more voracious than larvae of other instars. Laboratory reared beetles consumed more prey than field-collected beetles.

Sekhon and Bakhetia (1994) noticed that the yield had an adverse relationship with aphid incidence, indicating that every plant, increase in the pest population resulted in decrease in yield by 2.22-4.82 kg/ha. The values of the co-efficient of determination were highest (70-96 per cent) in the semi-log population model. In addition, very low probability levels from the analysis of variance indicated that this was the best model to explain the relationship between aphid incidence and crop yield.

Sinha and Rai (1994) studied the influence of relative humidity and temperature of 1-6 days prior to the date of observation on development of *L. erysimi* and found that the maximum relative humidity three days prior to observation was the most important factor in increasing the aphid population.

Basavaraju et. al. (1995) indicated the peak incidence of *Brevicoryne brassicae* during *kharif,* summer and *rabi*, while *L. erysimi* showed its dominance during *rabi* and early part of summer and *M. persicae* exhibited lower incidence in all the seasons except during summer.

Bhattacharya *et.al.* (1995) found that *L. erysimi* had a positive influence in the settlement and initial growth on mustard. Population of *L. erysimi* attained the greatest growth rate in the latter part of the vegetative stage of the crop and gradually declined during the flowering and fruiting stages. Maximum fecundity and the fastest rate of development were observed when the nymph fed on young leaves. Economic injury level (20-51 aphid/plant) was attained only in the vegetative stage when 35-40 per

cent of the crop was infested. The number of aphids recorded/100 plants showed a significant positive correlation with its infestation.

Singh *et al.* (1998) reported that the mustard aphid passed through 4 nymphal instars, the duration of each being 1-3 days on the 3 hosts. Total nymphal period of 9.2 days on BSH-1 was significantly more than that on RH 30 (8.0 days) and YSPb-24 was 18.4, 18.4 and 15.4 days, respectively. The prenatal period was significantly more on YSPB 24, (2.2 days) than on RH-30 (1.0 days) and BSH-1 (1.2 days). However, the natal period was significantly more on RH-30 39.6 nymph 31.53) compared with BSH-1 (28.4 nymph, 16-40) and YSPB-24 (24 nymph, 12-15). However, average mortality/female/day was 3.1, 3.8 nymph, which was showing equal susceptibility of all the hosts to *L. erysimi* incidence.

Manzar *et. al.* (1998) observed the impact of abiotic factors on the population dynamics of mustard aphid in eastern U.P during the rabi seasons of 1994 -96. *Lipaphis erysimi* was observed from the third week of January to the first week of March during 1995 -1996. A population peak of 654.7 aphids per 10 cm central twig was recorded in the third week of February during 1994 -1996, the aphid population was lower at 29.0 aphids per 10 cm central twig, climatic factors were correlated with the incidence of *Lipaphis erysimi.*

Srivastava *et. al.* (1998) observed the aphids on the flowering stage of *Brassica juncea* in Himanchal Pradesh. The range of maximum temperature 15.8 -24.7 °C , minimum temperature 10.2 – 16.0 °C and relative humidity 61 -65 % was found to be conductive for the rapid multiplication of the aphid on this crop. In addition, good rainfall in January to mid February was the main factor causing rapid aphid population while

rainfall in the last week of February or first week of March had a deleterious effect.

Sonar and Desai (1999) conducted a field experiment between November 1996 and March 1977 in Dapoli, India, to test, the reaction of eight Indian mustard varieties under natural infestation of *Lipaphis erysimi.*None of the varieties was free from infestation. TM -2 and Pusa Bold were found to be least susceptible, with mean *Lipaphis erysimi* populations of 28.91 and 35.98 aphids per 10 cm twig , respectively ,and a mean aphid index of 1.95 to 2.04.

Singh and Lal (1999) studied the severity of *Lipaphis erysimi*, infestation in Brassica *juncea* crop and its period of occurrence were not uniform during two successive crop seasons in India. The peak infestation of aphid (414.15 per 10 cm terminal shoot per plant) was recorded in the first year, while the maximum infestation (471.10 per 10 cm terminal shoot per plant) was recorded in the second year. The variable fluctuation in pest numbers during the two cropping seasons was attributed to climatic conditions.

Sachan and Sachan (2000) studied the behavioural and reproductive responses of the *Lipaphis erysimi* in relation to 50, 75 and 100% flowering phases of eight cultivars of *Brassica juncea* and one cultivar of *Sinapdsis alba*. The aphid population and infestation increased with the advancement of flowering and maximum population and infestation occurred when the crop reached 100 % flowering.Among the varieties *Sinapdsis alba,* Porbiraya and varuna were the most suitable host whereas RW 2-2, RW 15 -6 and B 85 were the least preferred.

Pande *et. al.* (2000) conducted a field study in Raipur (M.P.) to study the intensity and population fluctuation of *Lipaphis erysimi* on *Brassica juncea* in relation to the prevailing abiotic and biotic conditions. The aphid species infested the crop from 52nd to the 14th standard week (SW) with its peak (302.10 aphids per plant) during 7th SW in 70 – day – old crops. The minimum temperature between 7.1 and 15.1°C , maximum temperature between 24.9 and 29 °C and mean relative humidity between 61 and 65.5 % were found to be congenial for the proper development of aphid population.

Kulkarni and Patel (2001) conducted a field survey on the seasonal incidence of mustard aphid *Lipaphis erysimi* and reported aphid incidence between the first week of January and the fourth week of February with high incidence during the first week of February.

Vekaria and Patel (2002) studied the biology of mustard aphid and reported four nymphal instars. The mean nymphal period was 6.84±0.80 and 6.07± 0.65 days and adult longevity was 8.20 ± 1.12 and 8.62 ± 1.05 days, during which time an average of 26.92 ± 5.36 and 37.93 ± 8.93 nymphs developed, respectively, in the first and second set of insect under observations.

Gami *et. al.* (2002) studied population dynamics of mustard aphid at Junagadh, Gujarat, in relation to temperature, rain, humidity, radiation and atmospheric pressure. The incidence of mustard aphid on mustard crop commenced from fourth week after sowing with population levels of 0.05, 0.50 , and 0.40 aphid index per plant on Varuna,GM -1 and GM-2, respectively. In addition, the aphid populations gradually increased and reached peak levels of 4.60, 4.55 and 4.50 aphid index per plant,

respectively, during the twelfth week after sowing. On the other hand, the index slowly declined to 3.40, 3.35 and 3.50 per plant on Varuna, GM -1, and GM-2, respectively in the fifteenth week after sowing. The pest was active from November to February and the population ranged between 0.40 and 4.60 aphid index per plant on all three mustard cultivars. Correlation analysis showed a negative correlation of aphid population with maximum and minimum temperature, while the morning relative humidity and mean bright sunshine hours were not significant,

Nayak *et. al.* (2003) studied the seasonal abundance of mustard aphid on mustard,cabbage,cauliflower,knolkhol,radish and turnip and found the population of aphid per plant was lowest (3.51) on turnip and highest (6.08) on cabbage. The highest aphid population was recorded on the second week of January, when it reached 42.95, 22.95,22.30,17.35,16.32 and 11.72 on Indian mustard, cabbage, cauliflower, knolkhol, radish and turnip. Thereafter ,the aphid numbers declined. Overall, the mean aphid population during the season was highest (10.59) on radish and lowest (6.97) on turnip.

Srivastava (2005) also studied the effect of ecological conditions on the growth of population of *L. erysimi* . According to him the pest was very active in December and January and population ranged between 0.46 to 4.75 aphid index per plant of *Brassica campestris* in Allahabad (U.P).

(II) Economic losses:

Lee (1988) observed *Hyadaphis erysimi* (*L. erysimi*) and *M. persicae* in high number on cabbage, Chinese cabbage and leaf mustard from late autumn to early summer of following year in Taiwan. Aphid densities were established by using insecticides to manipulate infestation levels. There was no reduction in yield when infestation levels per leaf were 30 per cent on cabbage and 20 per cent on Chinese cabbage and mustard. Satisfactory control was achieved when insecticide was applied at 4 week intervals for cabbage and 3 weeks interval for Chinese cabbage and mustard during the peak period of occurrence of both species.

Atwal and Singh (1989) suggested economic threshold of 50 aphids per main shoot, after its population increase very rapidly. At increase of 1 aphid per plant tended to decrease the seed yield to 1.5 kg/ha.

Bakhetia *et al.* (1989) reported on the basis of aphid population per 10 cm. terminal shoot, ET levels were 61,54 and 71 aphids in 2 consecutive experiments. Maximum protection of mustard aphid neither always gave the highest yield nor the maximum cost benefit ratio.

Seth *et. al.* (1989) determined the economic threshold of *L. syrimi* on a radish seed crop of the variety Punjab Sufed. Sprays of oxydemeton methyl at 300 g a.i./ha were applied to set aphid population levels from 25 to 150 aphids/plant. The maximum cost benefit ratio was obtained at a level of 50 aphids/plant, requiring six sprays. Mid February was the most crucial time for spraying, as a delay of 7 days from this stage resulted in significant decrease in yield in the fixed spray schedule and at the level of 75 aphids/plant.

Vir *et.al.* (1990) estimated the losses caused by mustard aphid (*L. erysimi*) are variable in different years and different locations depending upon magnitude of its infestation in rapeseed and mustard were 87.9 per cent in Delhi and 91.3 per cent in Punjab.

On the basis of field studies in Assam (India), the economic injury level for *L. erysimi* on Var. *toria* was found to be 30-40 aphids/10 cm. of the shoot during the Ist and 2nd week of January, when 17.0 - 28.67 per cent of the twig were infested (Datta, 1992).

Singh *et. al.* (1993) studied the susceptibility of ten cultivars to infestation with *Lipaphis erysimi* and reported *B.nigra* and the *cultivara* BC2, HC2, T6342, RH7846, RH30 and Prakash, having greenish yellow flowers with scattered flower buds, were resistant. The full bloom stage of the cultivars was positively correlated with appearance of aphid in Haryana,India,yield losses averaged 38.20-46.56 % in susceptible and 2.86 -17.53 % in resistant cultivars.

Anon (1994) reported the avoidable yield losses were 30.11, 38.7, 46.8, 47.8 and 48.00 per cent in case of *B. juncea, B.carinata, B. napus* and *B. campestris* Var. Brown *sarson* at Kangra. Mean while, these were 29.1, 40.25, 37.66 and 33.33 per cent in *B. campestris* Cv. BS_2, yellow *sarson* Cv. K-88, Indian mustard Cv. *campestris* and Krishna, at Kanpur and 33.48, 28.47, 25.33 and 18.59 per cent in strain of *B. campestris* Var. yellow *sarson* Cv. DYS-842, *B.juncea* .RL-1359, *B. napus* Cv. FM-23 and *B. carinata* Cv. DLSC-1, respectively. The economic threshold was 50 aphids per plant with its infestation of 30 per cent *B. juncea* in Punjab, 19 (Av. 14 aphids/plant with 20 per cent infestation on *B. campestris* in Haryana, 13 to 15 (AV. 14 aphids/plant) on *B. juncea* in U.P.; and 28 per cent aphids on *B. campestris*

in Assam. From Hisar this level on *B. juncea* Cv. RH 30 and *B. napus* CV. GSL-1 was 4 to 5 aphids / plant

Singh and Sachan (1994) revealed that yield losses of *B. campestris* yellow *sarson* Var. PYS-6, due to *L. erysimi* were to the extent of 69.61 per cent in untreated check, whereas it was 6.354 to 56.91 per cent when aphids were allowed, to feed for the period of 20 -80.Delay in the aphid infestation by one day beyond 45 days of plant age resulted in an increase of 2.245 siliquae and 0.0622 g seed yield per plant and 0.024 g in 1000 grain weight. On every increase of one day in aphid exposure, the corresponding decrease was 2.134 siliquae and 0.611 g seed per plant and 0.0449 g in 1000-grain weight.

Nirmalendu et. al. (1995) conducted experiments during Rabi season with mustard Var. T -59 and studied the effect of different exposure periods to *Lipaphis erysimi*.They applied 10 treatments consisting of eight exposure periods and one control. The insecticide methyl demeton was applied at a conc. of 0.025% to control infestation after the specified exposure periods. Highest yield was recorded in completely protected plots and lowest in untreated control plots in both seasons.

The average yield losses were 52.93, 62.19 and 72.61 per cent in *B., carinata, B. napus* and *B. juncea,* respectively, at Ludhiana; in Hisar the cultivar *B. napus* was heavily damaged by aphid infestation with 33.28 per cent yield loss followed by 12.47 per cent in RH-30. The yield losses were 34.68 per cent in various strains of *B. juncea* against 37.50 per cent in Brown *sarson* (BS_2) at Bhatinda. At Pant Nagar maximum yield losses were 74.42 per cent in *B. carinata* and lowest 21.19 per cent in *B. juncea.* The yield losses were high for rapeseed cultivar i.e., 51.96 per cent in Brown

sarson and 63.88 per cent in yellow *sarson.* The losses were 46.98 in *B. nigra* and 48.7 per cent in *Eruca sativa* (Anon, 1995b).

Anon (1996) reported the average yield losses due to mustard aphid *L. erysimi* were 47.4 per cent at Ludhiana; 30.46 per cent at Hisar and 11.9 per cent at Navgaon on mustard *B. juncea* .

Lal *et. al.* (1997) observed the relative performance of 83 *Brassica* germ plasm against *Lipaphis erysimi* during rabi season. They revealed that two germ plasm (B -85 glossy and RW – white glossy) were highly resistant. Forty-two grem plasm were rated as susceptible, and five as highly susceptible to *L.erysimi.*

Lal *et. al.* (1997) observed the first incidence of *Lipaphis erysimi* after eight weeks of transplanting, with the mean aphid population increasing with time. The mean aphid population was lower in all intercropped than sole – cropped cabbage, with cabbage +berseem recording the lowest mean aphid population 8 – 16 weeks after transplanting.

Singh and Kothari (1997) studied intercropping effects of mustard aphid populations and reported as if intercropping with aromatic plant species could provide an environmentally safe method for aphid control,aphid infestation on a monocropping with *Artemisia annua, Coriandrum sativum* and other species. Intercropping with *foeniculum vulgare* resulted in a significantly lower aphid infestation.

Rohilla *et. al.* (1999) conducted field studies during rabi season and reported two colour morphs of *Lipaphis erysimi* (pale – green and yellow) .The pale – green morph of *Lipaphis erysimi* was the most abundant.

Vekaria and Patel (1999) conducted field studies during the rabi season in Gujarat to determine the biology of *Lipaphis erysimi* on three Indian mustard cultivars (GM – 1, Varuna and PM – 67). The nymphal period was shortest (5.88± 0.67 days) on PM -67 and longest (6.58 ± 0.65 days) on GM -1 (8.71±0.69 and 15.29± 0.69 days) and longest on PM -67 (10.36 ± 0.99 and 16.24 ± 1.09 days).Fecundity was lowest on GM -1, intermediate on Varuna and highest on PM -67.

Singh et. al. (2003) observed the aphid density, infestation level and index values for Vardan,Rohini and Varuna. The economic thresholds of *Lipaphis erysimi* were 15.61,22.08 and 19.49 aphid/10 cm central shoot of 0.55,0.55 and 0.51, respectively.The aphid density on Varuna was 28.33 aphid/10 cm.Terminal shoot and an infestation level of 36.91%, indicating an index value of 0.63. For Rohini these were 28.09 hid/10 cm terminal shoot,36.63 % and 0.62 and for Vardan 27.82 aphid /10 cm terminal shoot,34.35% and 0.60 respectively.

Singh and Singh (2000) studied the rate of population change of *Lipaphis erysimi* Kalt. in five cropping system of Indian mustard result indicated a very slow rate of population change of aphids in mustard grown with potato. A faster rate of population change was noticed until the end of January followed by a gradual rate of change until mid February and a negative rate of change after late February in mustard grown with chickpea and berseem.Higher and positive R.P.C.A was recorded in a mustard monocrop until mid February which had the highest positive R.P.C.A.Age of mustard plant, sowing time and crop diversity influenced the rate of population of mustard aphid.

Vekaria and Patel (2001) studied in the laboratory to determine the total number of generations completed by *Lipaphis erysimi* (Kalt.) between January and March. The aphid completed 11 overlapping generations at 21.9 °C and 52% RH during the first season and 8 generations at 23.7 °C and 57% RH during the second season. The average duration of each generation was 6.04 days during first season and 7.15 days during second season.

iii. <u>CONTROL MEASURES</u>:

On the basis of data of All India Co-ordinated Project on Oilseeds (1983-84) and reports of Bakhetia *et.al.* (1985) and Singh (1986) oxydemeton-methyl, chlorpyrifos, methamidophos, pirimicarb, phosalone, quinalphos, formothion, malathion and FMC 500 (Carbosulfan) have been found very promising against *L. erysimi* on mustard.

Kalra and Gupta (1986) recommended two sprays of phosphamidon (0.03%) for best control of mustard aphid to obtain its higher yield.

Singh *et. al.* (1986) suggested application of insecticides like dimethoate 0.03%, phosphamidon 0.025%, quinalphos 0.025%, oxydemeton methyl 0.025%, endosulfan and monocrotophos 0.04% as they provided effective control of mustard aphid. They further recommended their application at its threshold of 14 aphids per plant on 10 per cent of the plants (Singh and Yadav, 1988).

Vir and Henry (1987) suggested four sprays of 0.03% dimethoate 30 a.i EC at fortnightly intervals to get significantly higher yield and more economic returns.

Mathur *et. al.* (1988) suggested that aphid, *L. erysimi* causing damage to mustard crop during its growth phase and adversely affect the oil production should be minimized through certain alteration in date of sowing and application of K with N and P fertilizer alongwith the selective insecticidal application and exploration of natural enemies of this pest are the major components for evolving sensible integrated management approach on mustard.

Ramkishore and Phadke (1988) applied two sprays of oxydemeton methyl on 80 to 110 days old crop which resulted in the highest yield (4.00 - 4.55 tonnes/ha) compared to (2.02 - 2.33 tonnes/ha) for untreated crops.

Singh and Singh (1989) found that three foliar sprays of thiometon 25 EC, phosphamidon 85 SL, dimethoate 30 EC and methyl oxydemention 25 EC @ 0.3 kg a.i., / ha at nitrogen levels of 80 kg. N/ha were effective as granular insecticidal application of phorate, aldicarb and dimethoate @ 1.5 kg. a.i./ha. at 40 kg. levle of N.

Kotwal *et. al.* (1990) showed that a single application of adlicarb @ 10 kg/ha at flower initatioin stage of the mustard crop was sufficient to reduce the yield loss due to *L. erysimi*, and was found more economical than spraying with oxydemeton methyl .

Singh *et.al.* (1997) Studied the relative toxicity of five synthetic pyrethroids and monocrotophos against *L.erysimi* on mustard .They observed LC_{50} values for deltamethrin, taufluvalinate , fenvalerate, cypermethrin,, fenpropathrin and monocrotophos as 1.62X 10^{-7} , 1.21 X 10^{-6} ,9.22X 10^{-5} ,1.92X10^{-4} ,3.07X 10^{-2} ,7X 10^{-2} and 7.38X 10 - 5 %

respectively. Deltamethrin and taufluvalinate found more toxic than other pyrethroids used in this experiment.

Rouf and Kabir (1997) determined the effectiveness of the insecticides - malathion, fenitrothion, dichlorvos, phosalone, dimethoate, cypermethrin, cymbush, monocrotophos, diazinon and dimecron against *L. erysimi* on mustard for two years. It was observed that 3-4 sprays with either monocrotophos or malathion at 2.0 ml / liter of water effectively controlled the pest and gave an increased yield.

Sonkar and Desai (1998) tested eight insecticides against *L.erysimi* on mustard. Phosphamidon and dimethoate at 0.5% were found to be significantly superior to the remaining insecticides in reducing the infestation of *L.erysimi* and increasing the yield of mustard.

Kumari et. al. (1998) studied the effect of endosulfan in/on leaves of Indian mustard and reported that four levels of spraying (0.02 , 0.05 ,0.07 and 0.1 %) found effective in reducing populations of *L.erysimi* at 1,3,7, or 10 days after spraying.

Deka et. al. (1999) conducted a study to compare the efficacy of 5 insecticides (deltamethrin, phosphamidon, dimethoate, oxydemeton - methyl and fluvalinate) at 3 different concentrations against mustard aphid, *L.erysimi* population was obtained with fluvalinate followed by deltamethrin, phosphamidon and dimethoate.Oxydemeton -methyl showed the least effectiveness. The highest percentage reduction of *L.erysimi* population was observed with fluvalinate at 0.068 per cent.

Yadu and Dubey (1999) gave 0,20,40,60, or 80 Kg / N/ha and sprayed with methyl demeton. After 10 days yield increased. Incidence of *L.erysimi* increased with increasing N rate, and was timely spraying of insecticide was significantly superior to late spraying.

Chinnabbai (2000) assessed the efficacy of nine insecticides against the *L.erysimi,* Acetamiprid at 0.02%, was found to give the highest mortality (87.95%) 24 hours after treatment, significantly superior over all the other insecticides, Polytrin -C (0.06 %) and imidacloprid (0.017 %) gave 71.25 and 66.25% mortality respectively, proved to be the less effective alternatives to acetamiprid for the control of *L.erysimi* Chlorpyrifos was found to be the least effective.

Barai *et .al.* (2001) studied the toxicity of insecticides (monocrotophos chlorpyrifos, fenvalerate, cypermethrin, phosphamidon, endosulfan and dimethoate) on aphid and observed that phosphamidon and endosulfan gave the highest and lowest benefit: cost ratio, respectively. Chlorpyrifos and phosphamidon were more highly persistent than the other insecticides.

Mishra *et. al.* (2001) conducted a field experiment during the winter season to study the incidence of *L.erysimi* .They observed that the early sown crop (5 -October) had the lowest *L.erysimi* population (40.31/10 cm of top shoot) and highest yield (13.20 q /ha).Among the intercropping systems, only Indian mustard + gram registered lower mean pest incidence (24.61)than the sole Indian mustard (25.50).

Singh et al. (2001) tested petroleum ether extract of mustard seeds against third instar nymphs and adults of mustard aphid.The extract was very effective and caused 100% mortality at 2% concentration in 24 hours. Fecundity was also reduced significantly. Lower concentrations (1.5 & 1 %) were also effective but required longer time to cause complete mortality. This extract appeared to be a useful protectant for *Brassica* oil seed crop against mustard aphid.

Dari et al. (2001) conducted experiments to determine the field efficacy of metasystox, dimethoate, phosphamidon and cypermethrin against *L.erysimi* infesting *Brassica campestris* .They observed that the highest reduction in aphid population and the maximum yield were obtained upon treatment with phosphamidon (0.03%) and cypermethrin (0.01%),followed by metasystox (0.025%) and dimethoate (0,03%) after five days of treatment.

Sarmi et al. (2002) gave 11 different insecticide treatments on Indian mustard and reported that treatment with methyl -0-demeton 0.025 %, carbosulfan 0.04%, methyl parathion 2%, and monocrotophos 0.04% were highly effective against mustard aphid.Profenophos 0.05% and azadirachtin 0.00075 % were less effective. Two sprays of methyl -0- demeton 0.025% gave maximum seed yield (1575 Kg/ha). The treatment with phosphamidon 0.03% was more economical as it gave the highest cost benefit ratio (1:12.7) followed by methyl - 0 - demeton 0.025% (1:8.2), monocrotophos 0.04% (1:7.7) and methyl parathion 2% dust (1:6.6).

[illegible] and Prasad (2003) conducted an insecticidal trial against mustard aphid in New Delhi. The insecticides imidacloprid, cartaphydrochloride, ethofenprox, oxymethyl demeton, deltamethrin and nimbecidine were sprayed on *L.erysimi* .The reduction in aphid population one day after treatment varied from 9 to 75% in different treatments. The maximum aphid reduction was in deltamethrin 0.005% (75%) and least was in nimbecidine 0.03 % (24%).

[illegible] (2004) find that Imidacloprid controlled the aphid population when used as foliar spray treatment. The lower treatment rates at 20ga,I ha -1 proved sufficient to optimize the yield of mustard crop.

[illegible] and Singh (2005) studied the effect of nine compounds, namely 2 allelochemicals and 7 plants growth regulators (IAA, IBA, 2,4-D ,GA3 ,alar B-9, maleic hydrazide and cytokinin) using 3 concentrations (control ,64,256,1024 ppm) on 2 *L. erysimi* nymphal age groups.IAA and cytokinin treatments caused maximum inhibition on emrgence of both the nymphal stages. Emergence was significantly affected with IBA< 2, 4-D in first instar whereas in second instar, all the compounds decreased emergence, except for GA 3,

Srivastava and verma (2005) studied the toxicity of endosulfan, dimethoate, phosphamidon, triazophos, quinalphos and monocrotophos to the mustard aphid was determined under laboratory conditions. Mortality of the pest was recorded after 24 h of exposure to the insecticides.Phosphamidon was the most toxic, recording an LC_{50} value of

0.0000066, whereas endosulfan was the least toxic with LC_{50} value of 0.0004469.

[illegible] and Singh (2008) conducted a field experiment to determine the efficacy of thiamethoxam,endosulfan and cartap hydrochloride against *L.erysimi* .All the insecticides were applied at fortnightly intervals,twrice as foliar spary.Thiamethoxam reduced 96.82, 97.44, 99.86 and 99.72% aphid population on the seventh,fourteenth,twenty first, and twenty eighth day of first spray. Cartap reduced aphid population to 68.06, 92.29 and 58.85 % in first spray, while it reduced 59.28, 87.64 and 45.36% in second spray on 1.7 and 14 days of spraying respectively. Endosulfan also reduced the aphid population to 74.43, 88.80 and 87.68 % in first spraying and 56.29, 82.56 and 41.40 % in second spraying on first, seventh and fourteenth day of sparying, respectively.

Swarup and Lal (2007) studied relative toxicity of several insecticides in western Uttar Pradesh and reported fruitful results.Endosulfan, cartap and phosphamidon found effective in controlling the pest population..

MATERIALS AND METHODS

CHAPTER -THREE

MATERIALS AND METHODS

The investigation on ecological studies related to distribution and assessment of injury level of aphid, *Lipaphis erysimi* Kaltenbach infesting *Brassica campestris* for making judicious use of insecticides, were carried out at the Insectory of Department of Zoology and the laboratory of Department of Zoology, D.V. College, Orai during 2003-2004 to 2005-2006 by adopting the following studies.

(A) THE INSECT :

L. erysimi is a cosmopolitan species. In India, it is more prevalent in Punjab, Haryana, Bihar, Uttar Pradesh, Himachal Pradesh, West Bengal, Assam, Gujarat and Rajasthan.

Many genera and species of *Brassica* serve as primary food plants for mustard aphid. *Raphanus, Rorippa, Barbarea, Capsella, Iberis,Lepidium, Sinapis, Tnlaspi, Nasturtium, Matthiola and Sisymbrium* also serve as food plant occasionally. (Photo -1)

The mustard aphid exhibits polymorphism. The wingless and winged forms may occur simultaneously in the field. The wingless forms are small to medium sized, yellowish green, gray green or olive green with a white wax bloom. In humid conditions, the body is often more densely coated with wax

secreted by corrnicles of dorsum of the abdomen. The winged forms have a dusky green abdomen with dark lateral sclerites and dusky wing veins. Sometimes they are observed in large numbers on the undersides of leaves, which may curl and turn yellow. The size of wingless form is 1.4 -2.4 mm long and that of wing form 1.4 -2.2 mm.

In India, the life cycle of *L. erysimi* is anholocyclic.The mustard aphid appears in November on mustard crops. Initally a small colony of females colonise and reproduce parthenogenetically.The females are viviparous and give birth of nymphs. The growth of nymphs is very fast and within 1-2 weeks they become adult. Both wingless and winged forms develop. The developmental period varies with food plants for example, on mustard and cauliflower, it takes about 12 days but on radish, it takes 11 days only. The reproductive period of both forms varies considerably. The winged forms reproduce for 13 -17 days while wingless forms 12-22 days on different *Brassica* plants. A single female of winged form give birth of 35 -40 nymphs while wingless form give 70-135 nymphs at the rate of 3.5 nymphs / day in her life span. The mustard aphid is active throughout December to February passing through about 16 overlapping generations. The females survived for 26 -38 days on different host plants. The winged forms migrate from one field to others and spread the infestation.

Both nymph and adult aphids attack all aerial parts of the mustard plants, Aphids (nymphs and adults both) damage the plants by sucking their nutrients. Due to discharge of honeydew on leaves, the photosynthesis and

Photo .1- *Brassica campestris* field .

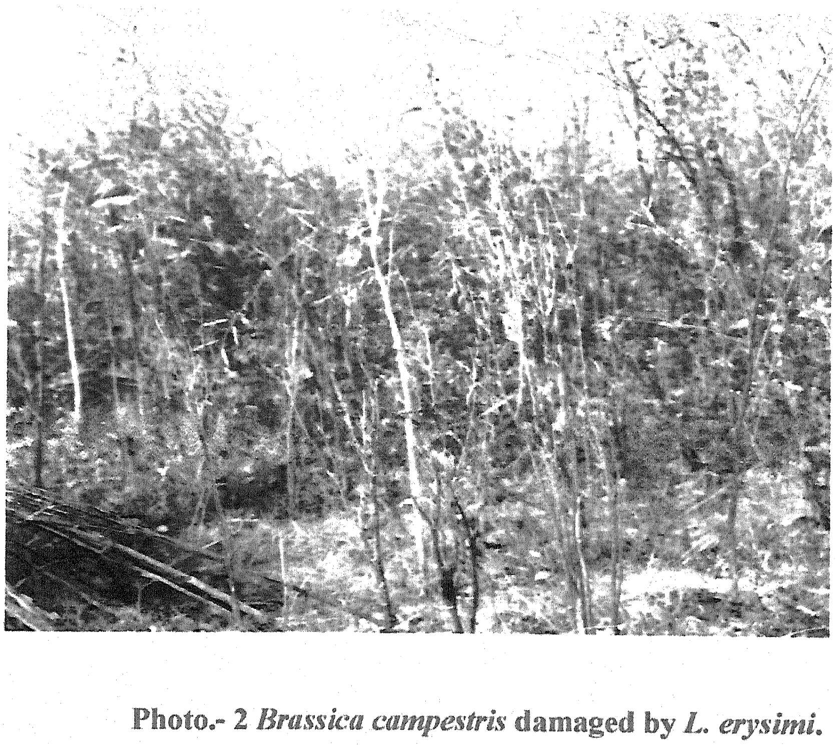


Photo.- 2 *Brassica campestris* damaged by *L. erysimi*.

Photo .3 - Mature nymphs of *L. erysimi.*

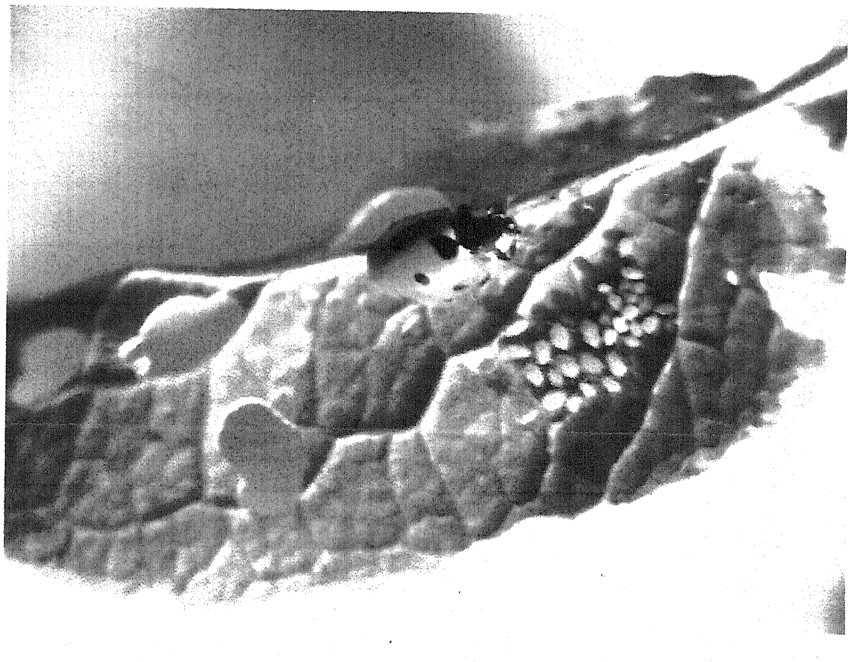


Photo. 4 - Young nymphs of *L. erysimi.*and *Coccinella* feeding on them .

respiration also affected, it affected the growth of mustard crop.

When attack of mustard aphid occurs in early stages of the plant, the leaves get discoloured, curled and withered. Plants remain stunted and ultimately dries up. Damage is more sever when aphid attacks in flowering and fruiting stages of the plant. The affected flowers get discolored and distorted and fall down, hence no pod is formed. Attacked pods are curled and no seed formation takes place. It seed set, they get shriveleed and there is drastic reduction in seed weight, oil content and seed viability. Under different agro - climatic conditions the mustard aphid damage the mustard crop from 35 to 90 per cent, particularly in north India.

(B) SELECTION OF THE VARIETIES:

In Orai (U.P.), the most popular varieties of mustard are Varuna, Rohini and Vardan, which were selected to carry out the investigations on ecological studies of mustard aphid to study its economic threshold levels for making judicious and timely use of plant protection technology. The variety Varuna was selected due to its adaptability for cultivation as a sole crop and even under mixed cropping system, while Rohini was included in trial due to its suitability in mixed cropping system of Potato + Rai and Vardan was taken due to its significance in late sowing practices.

The Management of aphid through need-based application of insecticides was also evolved only on Var. Varuna, as all the three varieties were being identically suffered from the ravages of *L. erysimi*.

(C) FIELD EXPERIMENTATION :

(a) The mustard varieties Varuna, Rohini and Vardan were sown in 5 x 3.00 m plots having 8 rows and 3 replications of each variety on 14.11.2003 during 2003-04 and on 25.10.2004 during 2004-05 to find out the population fluctuations in aphid population under different environmental conditions.

(b) The experiment for assessment of economic losses were laid out in randomized block design for maintaining different exposure periods by the application of phosphamidon 85 SL @ 0.03 per cent sprays (Table 1) , separately for each variety.

Table:1 Schedule for phosphamidon application for creating variation in aphid attack.

S.No.	Exposure Period	Number of Weekly sprays
1.	One Week exposure	6
2.	Two weeks exposure	5
3.	Three weeks exposure	4
4.	Four Weeks exposure	3
5.	Five weeks exposure	2
6.	Six weeks exposure	1
7.	Control	0

The experimental field was divided into three lengthwise replications leaving the area of 1 m in between two blocks as block border. The plot size was 5.00 x 3.00 m with 1 m border between two plots. A field border of one meter was provided around the field in order to facilitate the cultural operations. The crop was raised under normal recommended agronomical practices. The fertility of the field was kept at the level of 80:40:40 kg/ha N: P: K. The crop was free from weeds by weeding from time to time.

(c) The variety Varuna was sown on November 1, 2005 in randomized block design having three replications of following insecticidal treatments in 5 x 3 m plots.

- One spray on 5th January (66 days after sowing.)
- Two sprays on 5th and 19th January (66 and 80 days after sowing)
- Three sprays on 19th January and 2nd February (66, 80 and 94 days after sowing)
- Three sprays on 19th January, 22nd day and 16th February (80, 94 and 108 days after sowing)
- Two sprays on 2nd and 16th February (94 and 108 days after sowing)
- One spray on 16th February (108 days after sowing)
- Untreated (Control)

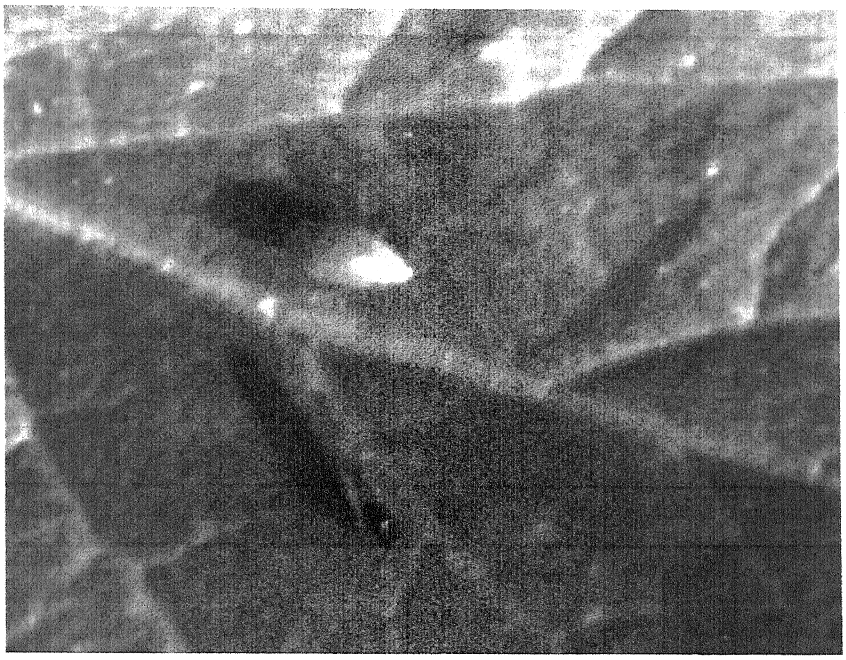


Photo.5 - Nymph and Winged *L. erysimi.*

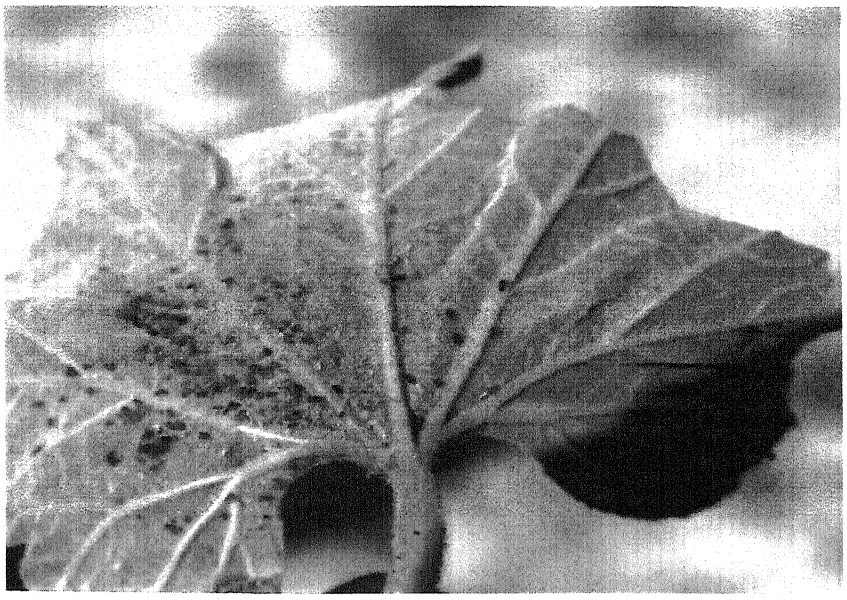


Photo. 6 - Honey dew on leaf surface.

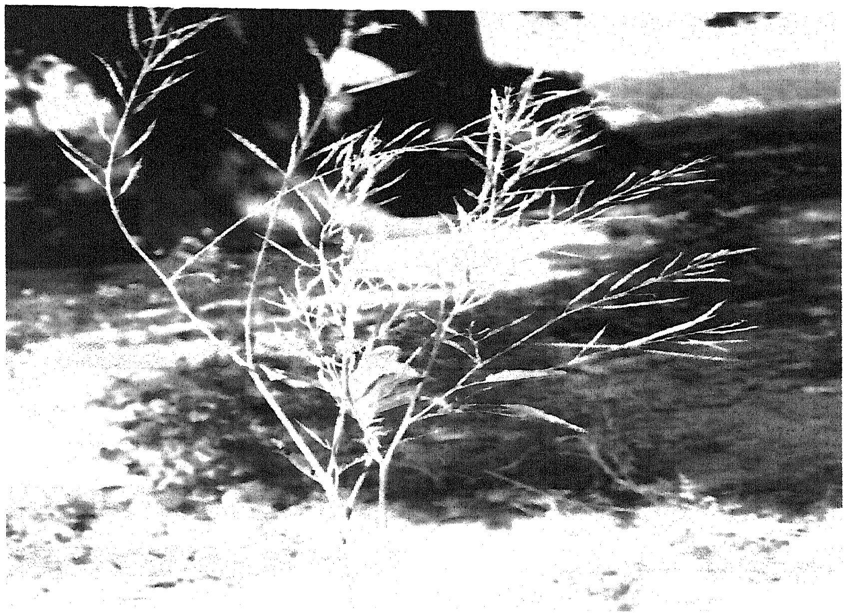


Photo. 7- Defoliated plant of *B.campestris*.

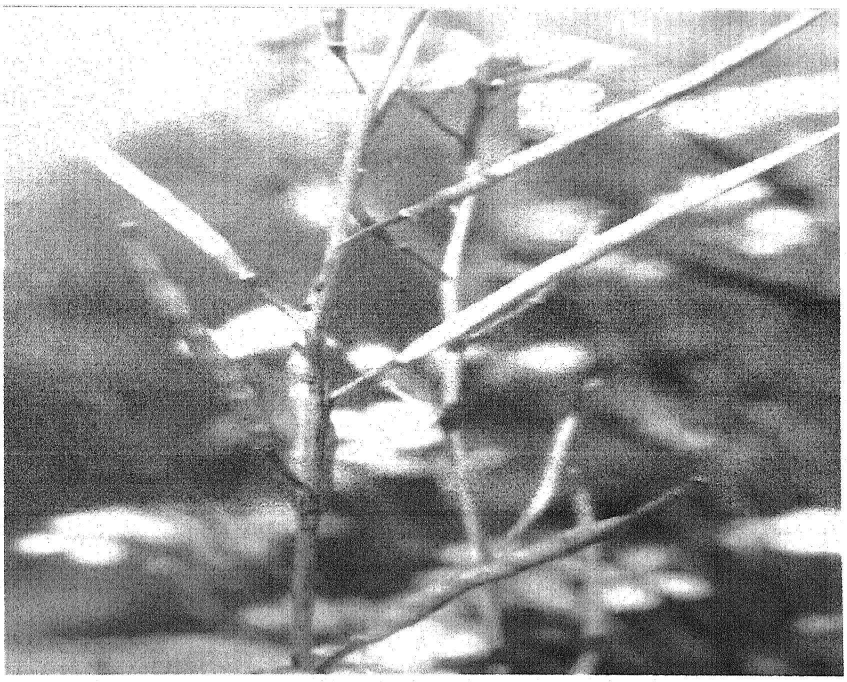


Photo.8 -Effected seed pods and flowers of *B. campestris* .

The insecticidal treatments were started immediately after appearance of aphids when aphid intensity was reaching at the economic threshold level of 15.61 aphids per plant on variety Varuna with an index of 0.55. The above mentationed technique for field experiments has been adopted from (Anon. 1994) and Bakhetia *et al.* [illegible].

(D) OBSERVATIONS :

(a) Estimation of aphid population:

The observation on aphid intensity, infestation and indices were collected at weekly intervals during both the years and the population of natural enemies was recorded simultaneously. The intensity of the aphid population of mustard aphid was observed on 10 randomly selected plants on 10 cm top shoot/ inflorescence of the main shoot. The population was counted *in situ* as per techniques of All India Co-ordinated Research Project on oilseeds during recent years and has been followed by Bakhetia *et al.* (1989). The infestation of the aphid was determined on the basis of pest population prevailing on the 10 randomly selected plants, whereas aphid infestation indices were also observed by adopting the following methodology of Pradhan *et al.* (1960), Prasad and Prasad (1960) and Mathur and Singh (1968b).

Grade 0 No aphid infestation or plants completely free from aphid.

Grade 1 Inflorescence having up to 15 aphids on them but they do not show any sign of injury.

Grade 2 Infestation moderately more than Grade-1, Aphid colonies scattered on leaves, stems, inflorescences and siliqua. Little curling and yellowing of leaves and siliquae.

Grade-3 Leaves, stems, inflorescence and siliquae densely populated by aphid. Curling and yellowing of leaves and siliquae were more evident.

Grade-4 Very heavy population of aphid on plants, leaves, inflorescence and siliquae showing symptoms of drying.

Grade-5 Complete drying of plants due to heavy infestation of aphid.

(E) ESTIMATION OF APHID POPULATION IN INSECTICIDAL TRIALS :

The data on aphid intensity, infestation and indices were recorded after 1 and 8 days of spraying by adopting the similar techniques, however, in the evaluation of time of insecticidal application only aphid intensity and indices were recorded.

(F) OBSERVATION ON APHID PREDATORS :

The population of grubs and adults of different species of coccinellid predators was jointly recorded on 10 randomly selected plants, by counting separately their grub and adults at weekly intervals of each variety.

(G) OBSERVATIONS ON PLANT CHARACTERS :

The heritable characteristics of each variety were recorded by grouping these characters into two categories i.e., general plant characters and numerical plant characters to determine the role of these characters in avoiding the plants themselves from aphid attack. These characters were recorded with the help of the Plant Breeders and teaching staff of Botany Department of D.V College, Orai.

(H) ANALYSIS OF DATA :

(i) Population Dynamics And Forecasting Models :

The weekly data on intensity, infestation and indices of *L. erysimi* on all the three varieties namely Varuna, Rohini and Vardan were computerized to find out their relationship with prevailing temperature, humidity, wind speed, evaporation rate and age of the crop. The simple correlation co-efficient values along with simple and multiple regression equations were calculated to determine the population dynamics of *L. erysimi* and its forecasting models on all the three varieties of mustard.

(ii) Varietal Resistance :

The varietal resistance in the promising cultivars viz., Varuna, Rohini and Vardan of *B. juncea* group against aphid infestation were determined on the basis of their physical plant characteristics including plant height,

branching, duration and time and type of following arrangement of siliquae, time of maturity, test weight and oil content etc. The data of mean intensity, infestation and indices of *L. erysimi* were computerized with plant characteristics to find out their response in improving the yield of each variety.

(iii) <u>Rate Of Multiplication Of *L. erysimi* :</u>

The rate of multiplication of aphid, *L. erysimi* was determined from the weekly data obtained on its intensity, infestation and indices of all these varieties by dividing their weekly increased values from the number of days to calculate the rate of aphid increase within a day.

(iv) <u>Assessment Of Economic Losses</u>:

(a) <u>Economic Injury Level</u>

The economic injury level was estimated by computing the total aphid intensity (X) and Yield (Y) in corresponding treatments as per technique of Stone and Pedigo (1972) and Atwal and Singh (1990). To calculate the co-efficient of regression (b) and gain threshold for insecticidal application, the following formulae were used:

$$\textbf{Grain threshold (GT)} = \frac{\textbf{Cost of insecticidal treatment / ha}}{\textbf{Cost of produce per Kg.}}$$

$$\textbf{Economic Injury Level (EIL)} = \frac{\textbf{Gain threshold}}{\textbf{Coefficient of regression (Aphid intensity Vs. Yield)}}$$

Photo. 9 - Every part of plant affected by *L. erysimi*

Photo. 10 - *Coccinella* feeding on aphids.

The equivalent value of economic injury level to aphid infestation and indices were calibrated by incorporating the aphid intensity level in the regression equations of aphid intensity (X) Vs. Aphid Infestation (y) and Aphid Intensity (X) Vs. Aphid. Indices (Y) respectively for all the three varieties during both the years.

(b) Economic threshold :

As the systematic insecticides require at least 3 days for complete translocation in plant system and creating toxicity against sucking pests like aphid on *B. campestris* . Therefore, the economic threshold (ET) was determined as the population three days prior to economic injury level (EIL) from the regression equation of the aphid intensity and age of the crop. The prevailing aphid indices and infestation were obviously recorded against the calculated economic threshold from respective regression equation. The economic threshold of aphid intensity, infestation and indices were determined separately for each variety.

(c) Assessment of losses :

The yield losses were determined based on the yield obtained in the completely protected and unprotected plots.

(I) ASSESSMENT OF BIO-EFFICACY OF PHOSPHAMIDON:

The bio efficacy of the treatment was observed at each observation by computerizing the data after their transformation to X value for calculating the critical differences between the prevailing aphid population and its indices.

TABLE - 2

Environmental conditions prevailing in aphid infestation period during 2004.

Date of observation		Temparature °C		Relative Humidity %		Wind speed km/hr	Evaporation rate (mm/day)	Total weekly rainfall(mm)	Age of crops (Days)
		Max.°C	Min. °C	Morning	Evening				
January	I	24.00	8.66	84.33	58.33	1.05	1.00	Nil	52
	II	25.14	9.20	72.28	53.71	2.08	2.42	19.90	59
	III	19.57	10.71	90.14	82.28	4.16	1.00	Nil	66
	IV	21.00	7.28	79.00	51.00	2.96	2.00	Nil	73
	V	25.14	11.42	75.71	49.85	4.00	2.85	Nil	80
February	I	23.28	9.14	79.57	51.71	1.42	2.85	Nil	87
	II	22.00	9.42	84.14	57.57	4.13	2.85	19.40	94
	III	25.42	11.14	72.42	47.00	3.69	3.28	Nil	101
	IV	24.42	10.28	66.57	40.85	1.60	4.14	Nil	108
March	I	27.28	11.42	56.28	36.28	3.75	5.00	Nil	115
	II	29.85	13.85	55.28	32.42	4.77	6.00	Nil	122
	III	33.57	17.85	60.14	39.42	6.54	6.20	2.40	127

Fig.1 Environmental factors prevailing in aphid infestation period during 2004.

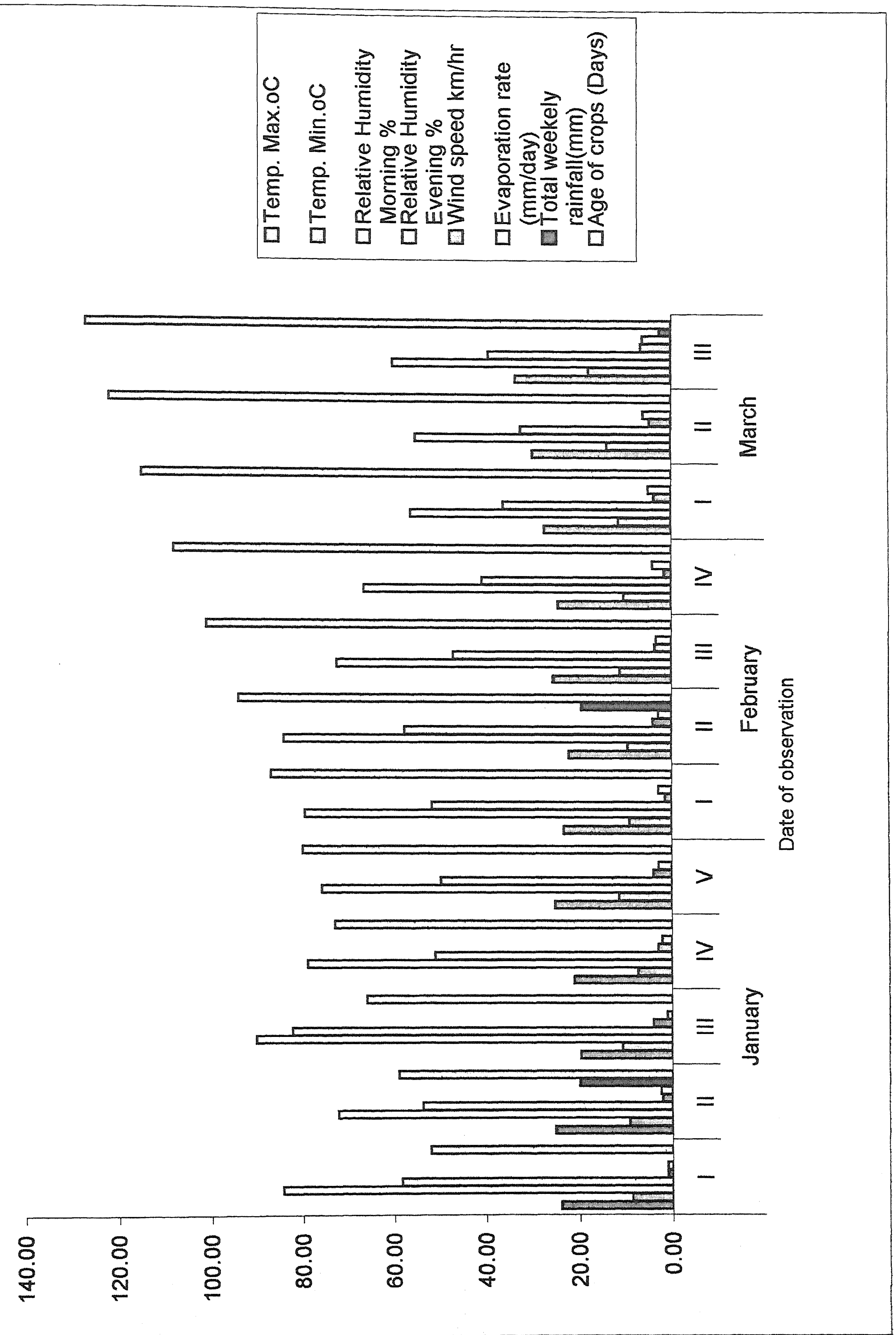
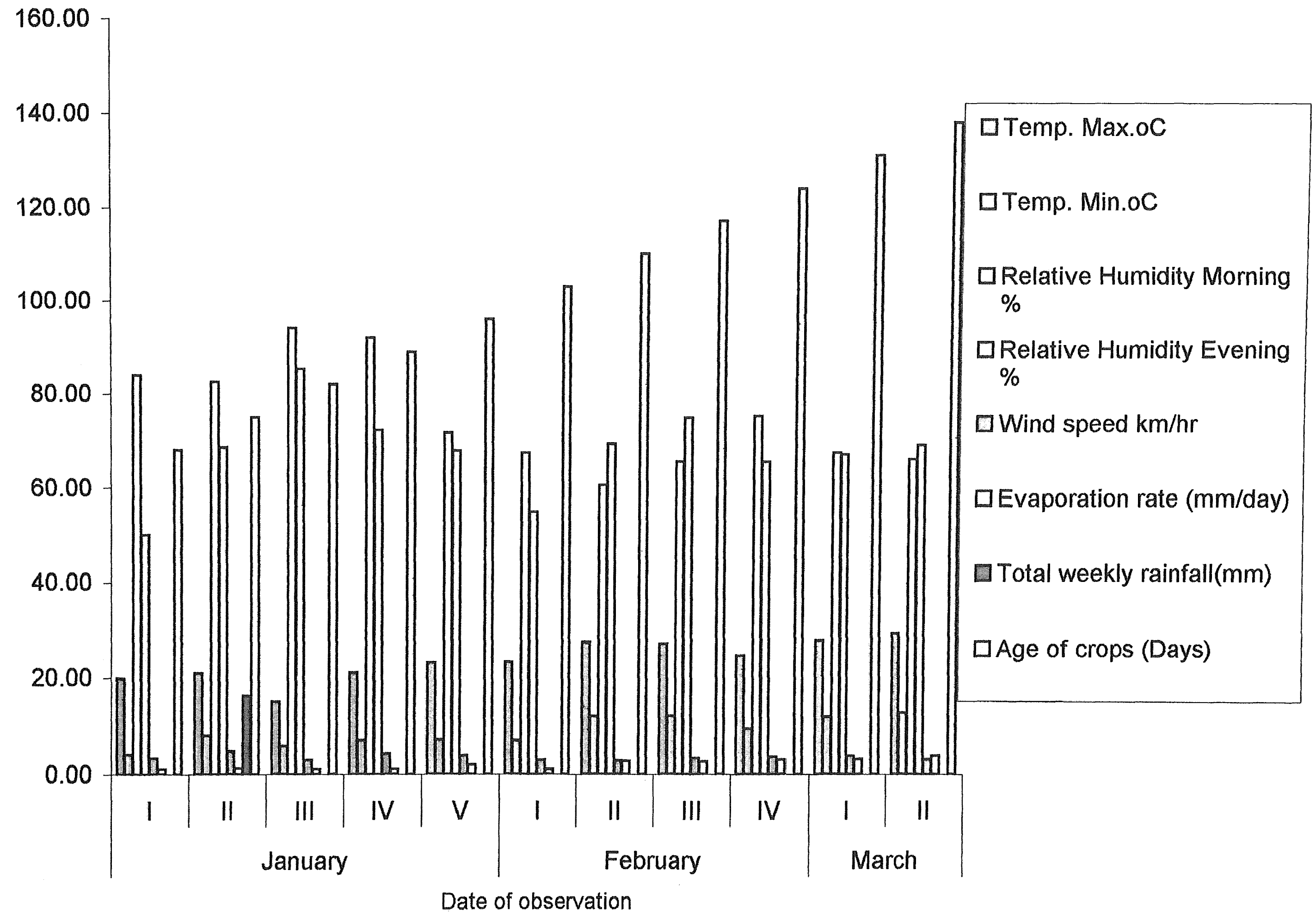


TABLE - 3

Environmental conditions prevailing in aphid infestation period during 2005.

Date of observation		Temperature °C		Relative Humidity %		Wind speed km/hr	Evaporation rate (mm/day)	Total weekly rainfall(mm)	Age of crops (Days)
		Max.°C	Min. °C	Morning	Evening				
January	I	19.90	4.20	84.00	50.00	3.35	1.00	Nil	68
	II	20.82	8.02	82.42	68.57	4.80	1.28	16.20	75
	III	15.00	5.87	94.14	85.28	2.91	1.00	Nil	82
	IV	21.02	7.00	92.00	72.28	4.29	1.00	Nil	89
	V	23.14	7.14	71.57	67.85	3.90	2.00	Nil	96
February	I	23.25	6.98	67.42	55.00	3.00	1.00	Nil	103
	II	27.40	11.97	60.50	69.20	2.88	2.71	Nil	110
	III	27.05	12.00	65.40	74.80	3.28	2.57	Nil	117
	IV	24.57	9.42	75.20	65.40	3.64	3.00	Nil	124
March	I	27.81	11.81	67.40	67.00	3.83	3.14	Nil	131
	II	29.20	12.70	66.00	69.14	3.11	3.85	Nil	138

Fig.2 Environmental factors prevailing in aphid infestation period during 2005.



The economics of insecticidal treatments was calculated to see the impact of varying insecticidal treatments.

(J) METEOROLOGICAL OBSERVATIONS :

The prevailing temperature, humidity, wind speed and evaporation rate etc. were collected from the Observatory of the Deptt. of Botany of the College (**Table 2 & 3 and Fig. 1 & 2**).

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RESULTS AND DISCUSSION

CHAPTER - FOUR

RESULTS AND DISSCUSSION

The investigation on population dynamics and assessment of economic injury level of *Lipaphis erysimi* Kaltenbach (Aphididae : Homoptera) was carried out on three most popular varieties of mustard *Brassica juncea* Czern. & Coss. being grown in Orai (Jalaun)in sole and mixed cropping systems under both irrigated and rainfed conditions. A series of experiments was laid out during 2003-04 and 2005-06 at mustard crop field and the Insectory of Department of Zoology of the D.V. College, Orai. The crop was kept under constant observations during this study for recording the population fluctuations in aphid in relation to biotic and abiotic factors of the environment nad subsequently treated with insecticidal sprays to create varying pressure of the aphid population for determining the economic injury level, with an ultimate aim to develop a fore-casting model for out break of the aphid and to evolve threshold level for applying insecticidal treatment for its management.

The main features of the findings of this study are being discussed in following pages under appropriate heads.

TABLE - 4

Seasonal abundance of mustard aphid for variety Varuna during 2004.

Date of observation		Age of crop (days)	Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
January	17	66	2.80	53.33	0.60
	24	73	10.33	76.66	0.76
	31	80	101.66	83.33	1.76
February	7	87	375.00	96.66	3.16
	14	94	403.00	90.00	3.00
	21	101	361.00	76.66	3.00
	28	108	0.00	0.00	0.00
Mean			179.25	68.09	1.75

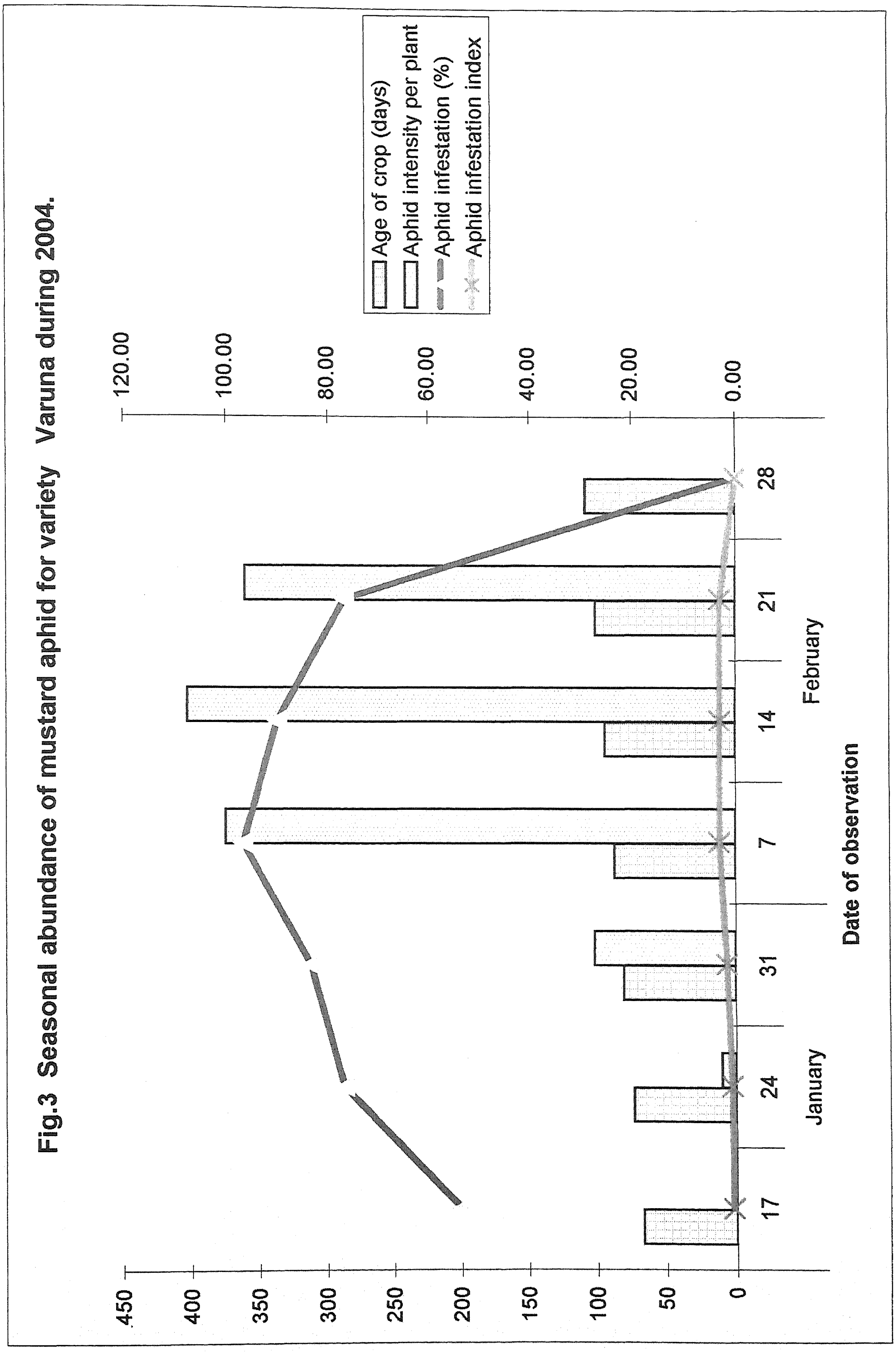


Fig.3 Seasonal abundance of mustard aphid for variety Varuna during 2004.

TABLE - 5

Seasonal abundance of mustard aphid for variety Rohini during 2004.

Date of observation		Age of crop (days)	Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
January	17	66	3.00	63.33	0.60
	24	73	26.66	86.66	0.96
	31	80	133.50	86.66	2.16
February	7	87	383.33	93.33	3.33
	14	94	391.66	96.33	3.16
	21	101	250.00	86.66	3.16
	28	108	0.00	0.00	0.00
Mean			169.73	73.32	1.91

Fig.4 Seasonal abundance of mustard aphid for variety Rohini during 2004.

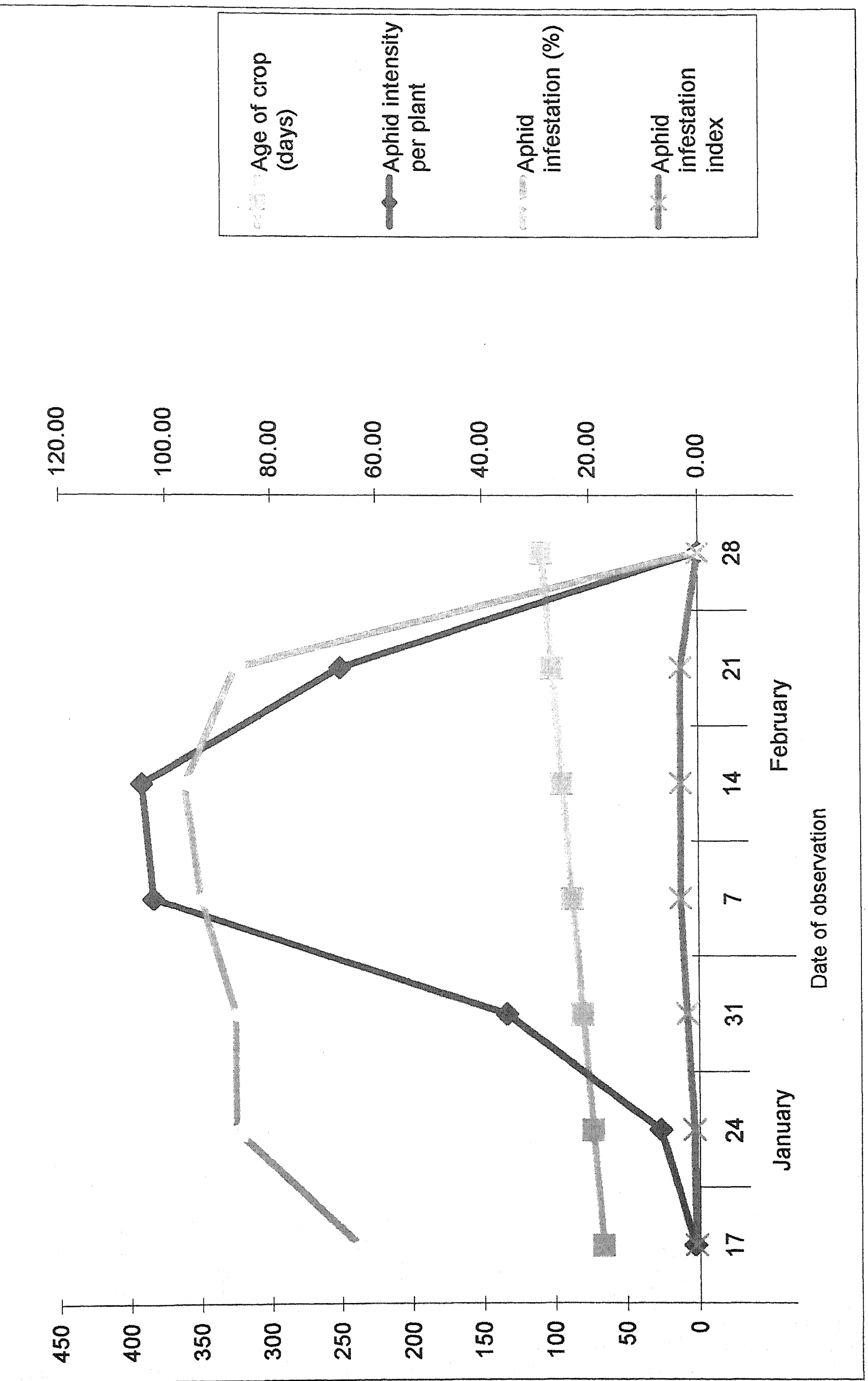


TABLE - 6

Seasonal abundance of mustard aphid for variety Vardan during 2004.

Date of observation		Age of crop (days)	Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
January	17	66	3.00	60.66	0.60
	24	73	31.66	83.33	0.83
	31	80	233.33	86.66	2.00
February	7	87	271.66	93.33	3.33
	14	94	358.33	90.00	3.00
	21	101	306.00	80.00	3.00
	28	108	0.00	0.00	0.00
Mean			172.09	70.56	1.82

Fig 5. Seasonal abundance of mustard aphid for variety Vardan during 2004.

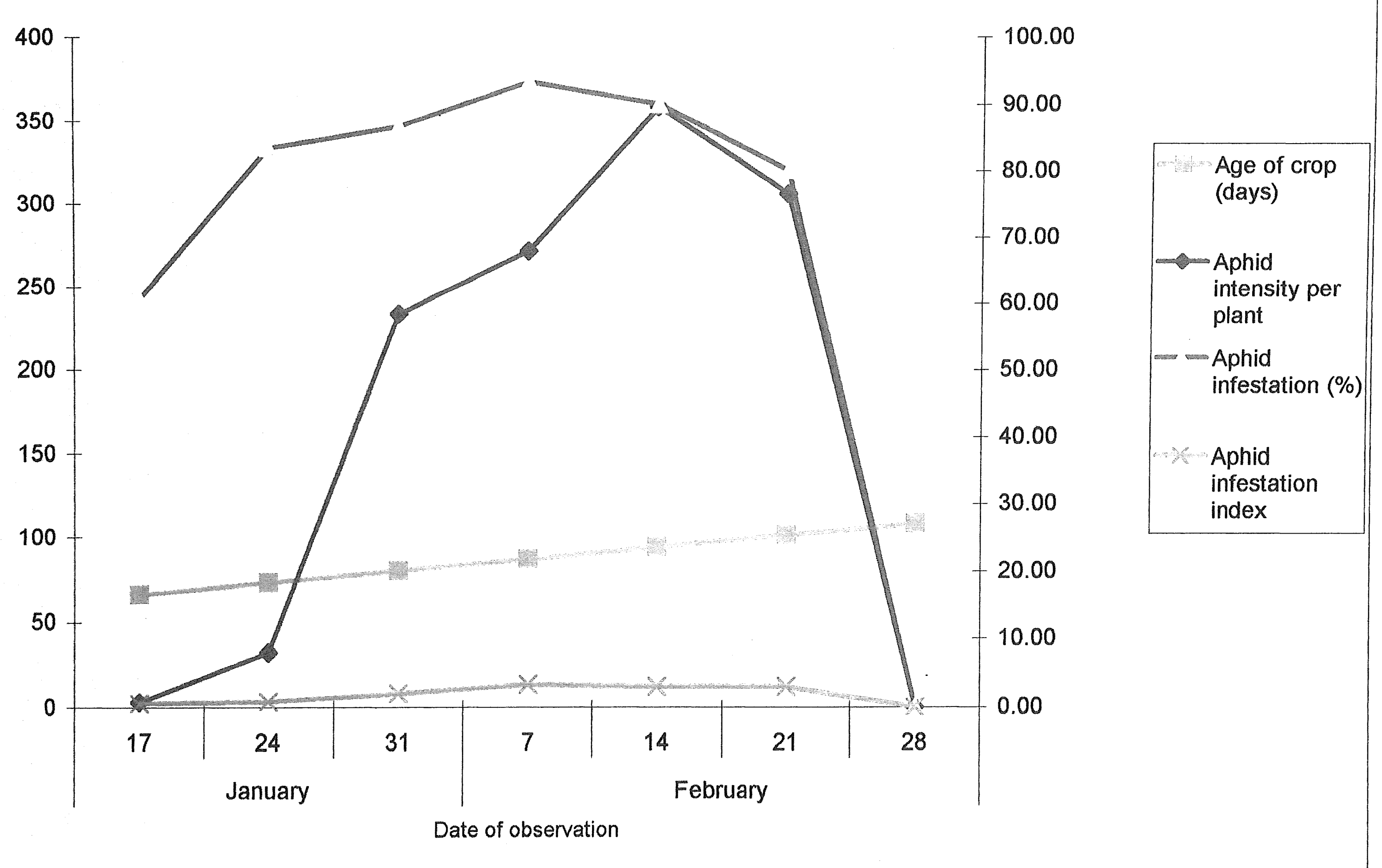


TABLE - 7

Seasonal abundance of mustard aphid for variety Varuna during 2005.

Date of observation		Age of crop (days)	Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
January	16	82	1.33	40.00	0.43
	23	89	24.66	76.66	1.50
	30	96	183.33	86.66	2.00
February	6	103	264.33	60.00	1.83
	13	110	231.66	43.33	1.50
	20	117	0.00	0.00	0.00
Mean			117.55	51.00	1.21

Fig 6. Seasonal abundance of mustard aphid for variety Varuna during 2005.

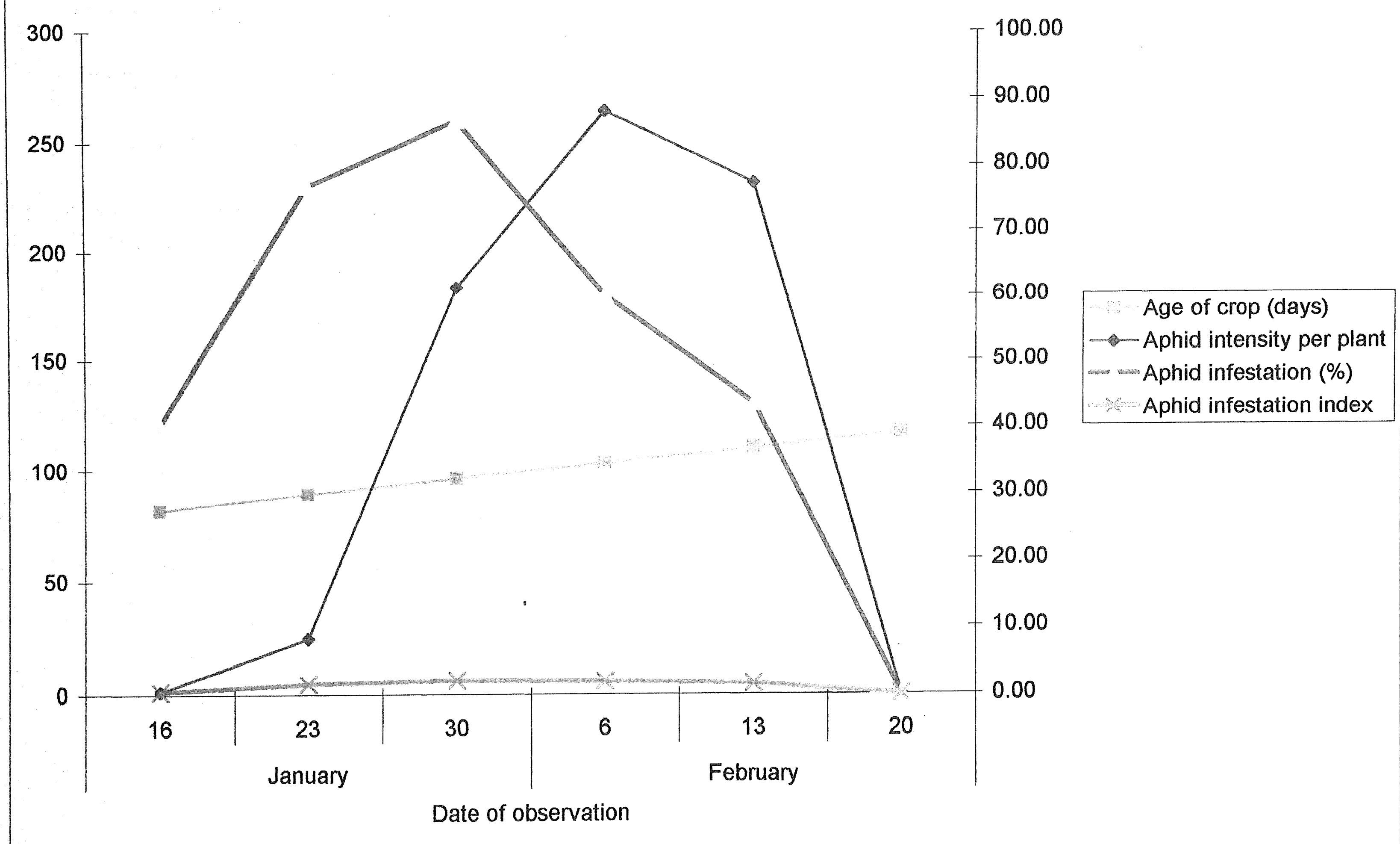


TABLE - 8

Seasonal abundance of mustard aphid for variety Rohini during 2005.

Date of observation		Age of crop (days)	Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
January	16	82	1.33	53.33	0.46
	23	89	23.33	86.66	1.50
	30	96	125.00	96.66	2.33
February	6	103	188.66	66.66	1.83
	13	110	176.83	53.33	1.50
	20	117	0.00	0.00	0.00
Mean			85.85	59.44	1.27

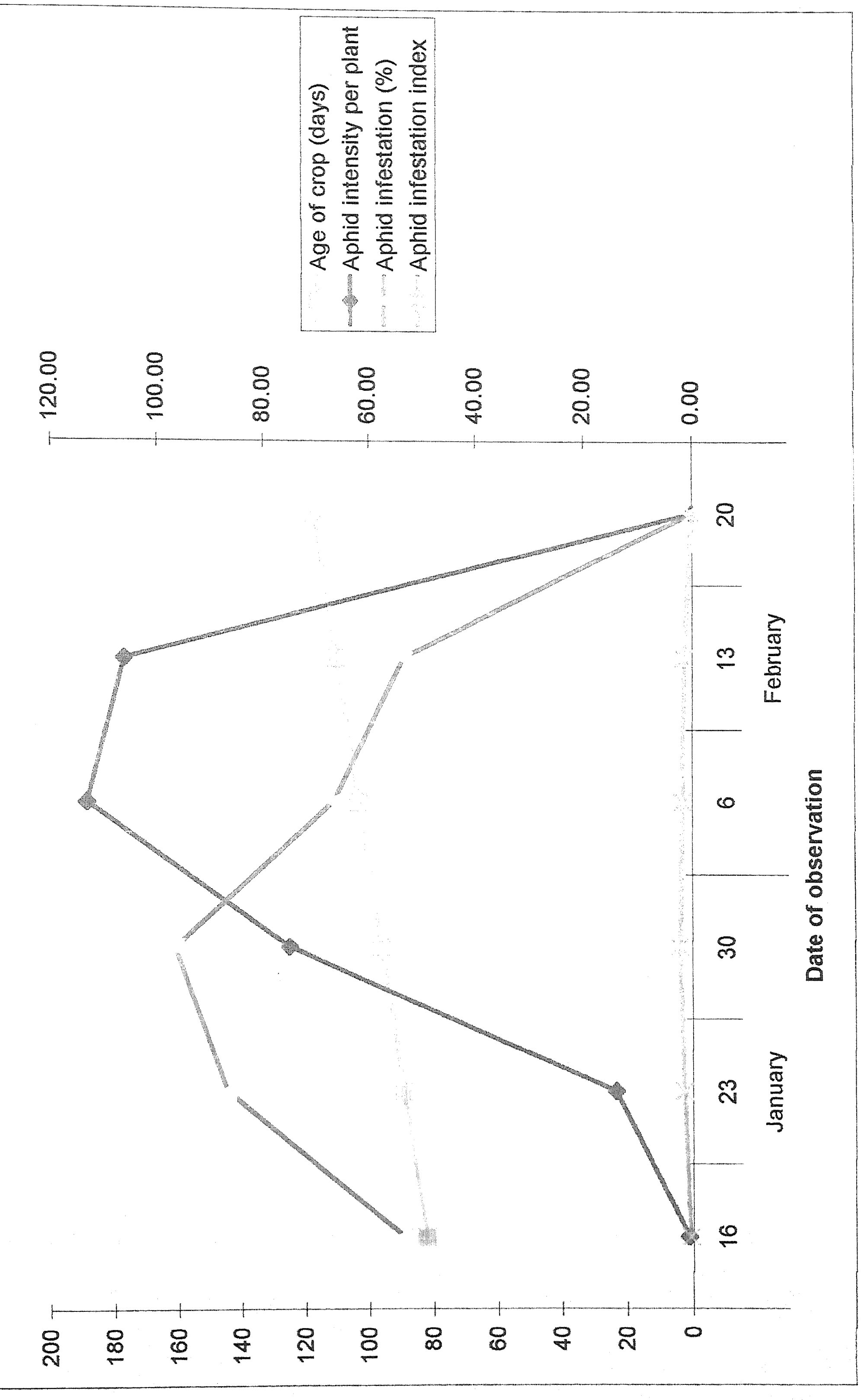


Fig 7. Seasonal abundance of mustard aphid for variety Rohini during 2005.

1. POPULATION DYNAMICS OF *L. ERYSIMI* :

The data recorded on the seasonal incidence indicating the intensity of the mustard aphid on 10 cm. top shoot length of the main shoot per plant along with its infestation and its indices, were collected at weekly intervals as per techniques of All India Co-ordinated Research Project on Oilseed ([illegible]) ([illegible]) and adopted by [illegible] The impact of environmental factors on aphid intensity, infestation and indices has been calibrated ([illegible]).

(i) Aphid Intensity In Relation To Environment Factors:

It is obvious from the data on aphid intensity ([illegible]) and environmental factors ([illegible]) that aphid *L. erysimi* appeard (2.80 and 1.33/plant) on all the used varieties of mustard during both the years in third week of January when maximum temperature was below 200 ^{0}C along with more than 90 per cent morning relative humidity, having evaporation rate 1.00 mm/day. As these conditions prevailed after 19.9 and 16.2 mm total weekly rainfall during these years in the 2nd weak of January. Aphid intensity reached at its peak 403.0 aphids / plant on Varuna, 391.66 on Rohini and 358.3 on Vardan in the first year during middle of February, probably because of RH 9.14 per cent (morning) associated with 22^{0}C maximum and 9.42 ^{0}C minimum temperature and suddenly reduced thereafter, because of rise in maximum temperature above 25 ^{0}C, minimum 11.140C and reduction in relative humidity to 72.42 and 47.00 per cent in

morning and evening hours of the day which were followed by rise in evaporation rate 3.28 mm/day in the third week of February. Similar situation of the temperature - maximum (23.25 ^{0}C) and minimum (6.98 ^{0}C) with relative humidity (67.42 per cent) in the morning hours of the day during first week of February was most conducive for enhancing aphid intensity to 264.33 aphids/ plant on Varuna, 188.66 on Rohini and 268.33 on Vardan in the second year, which was suddenly reduced with the rise in temperature, maximum above 27.40, minimum 11.97^{0}C and relative humidity 60.50 per cent as these were enhancing evaporation rate from 2.00 to 2.71 mm per day in the second week of February. An adverse effect of total weekly rainfall of 19.4 mm was also observed during the first year on variety Varuna on aphid population during the middle of January. The situation was identical on Rohini and Vardan cultivars during both years (2004 and 2005).

The aphid population was found completely eliminated on all three varieties of mustard (Varuna, Rohini and Vardan) by the end of February during first year and only upto 20th of February during the second year. As by this time the maximum and minimum temperature were 24.42 and 10.28^{0}C along with 66.57 and 40.85 per cent morning and evening relative humidity having 3.69 Km/hr wind speed of the preceding week had proved detrimental for aphid multiplication during 2003-04 Meanwhile, a rise in temperature more than 27^{0}C (maximum) and 12.00 °C (m.m) associated with less then 70 per cent relative humidity and more than 2.88 Km/hr wind speed continuously upon the middle of February became inconductive for aphid multiplication in the second year .

TABLE - 9

Seasonal abundance of mustard aphid for variety Vardan during 2005.

Date of observation		Age of crop (days)	Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
January	16	82	1.40	43.33	0.40
	23	89	35.33	83.33	1.50
	30	96	124.33	93.33	2.16
February	6	103	268.33	56.33	1.83
	13	110	215.16	46.33	1.50
	20	117	0.00	0.00	0.00
Mean			107.42	53.77	1.23

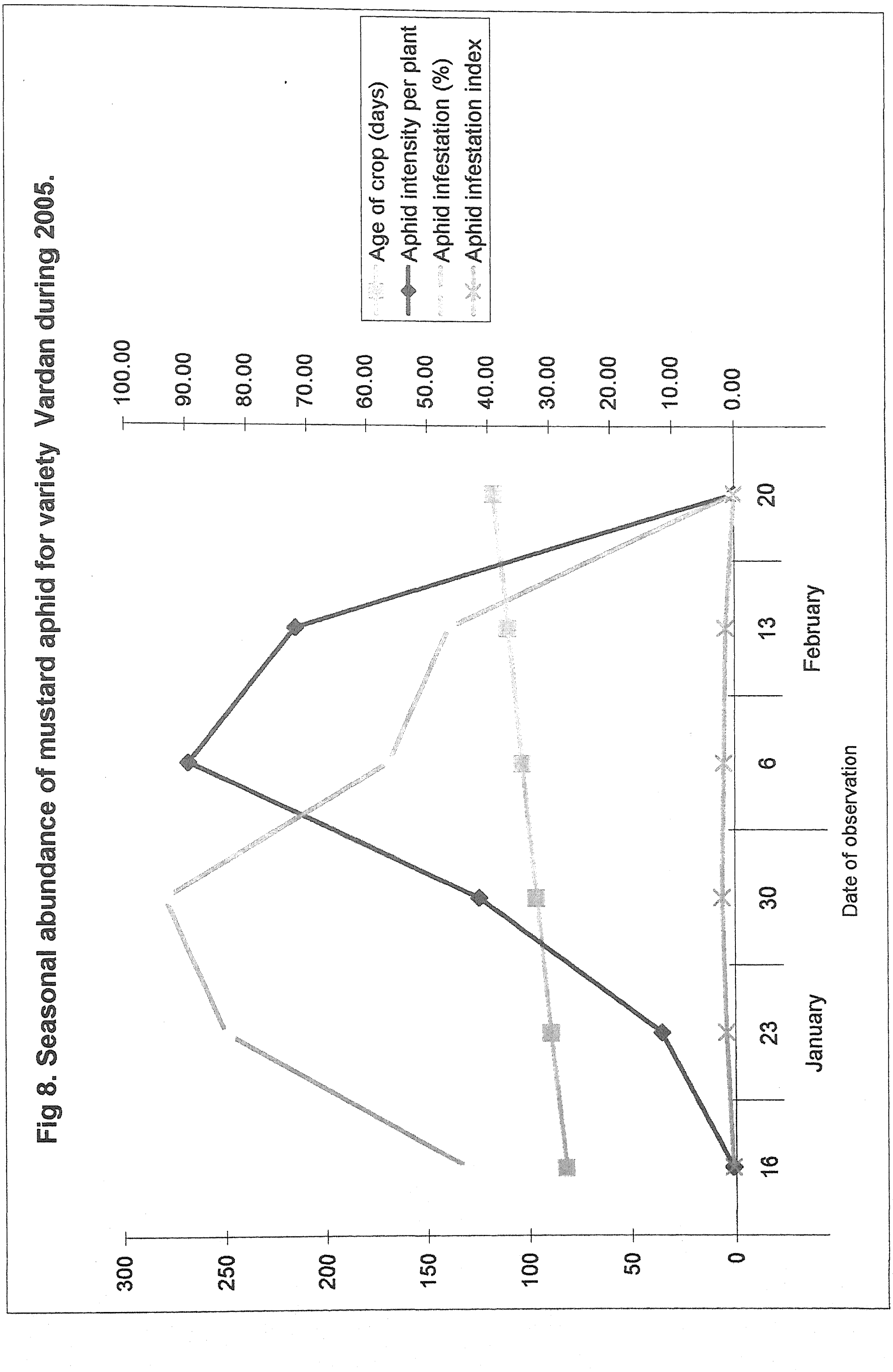


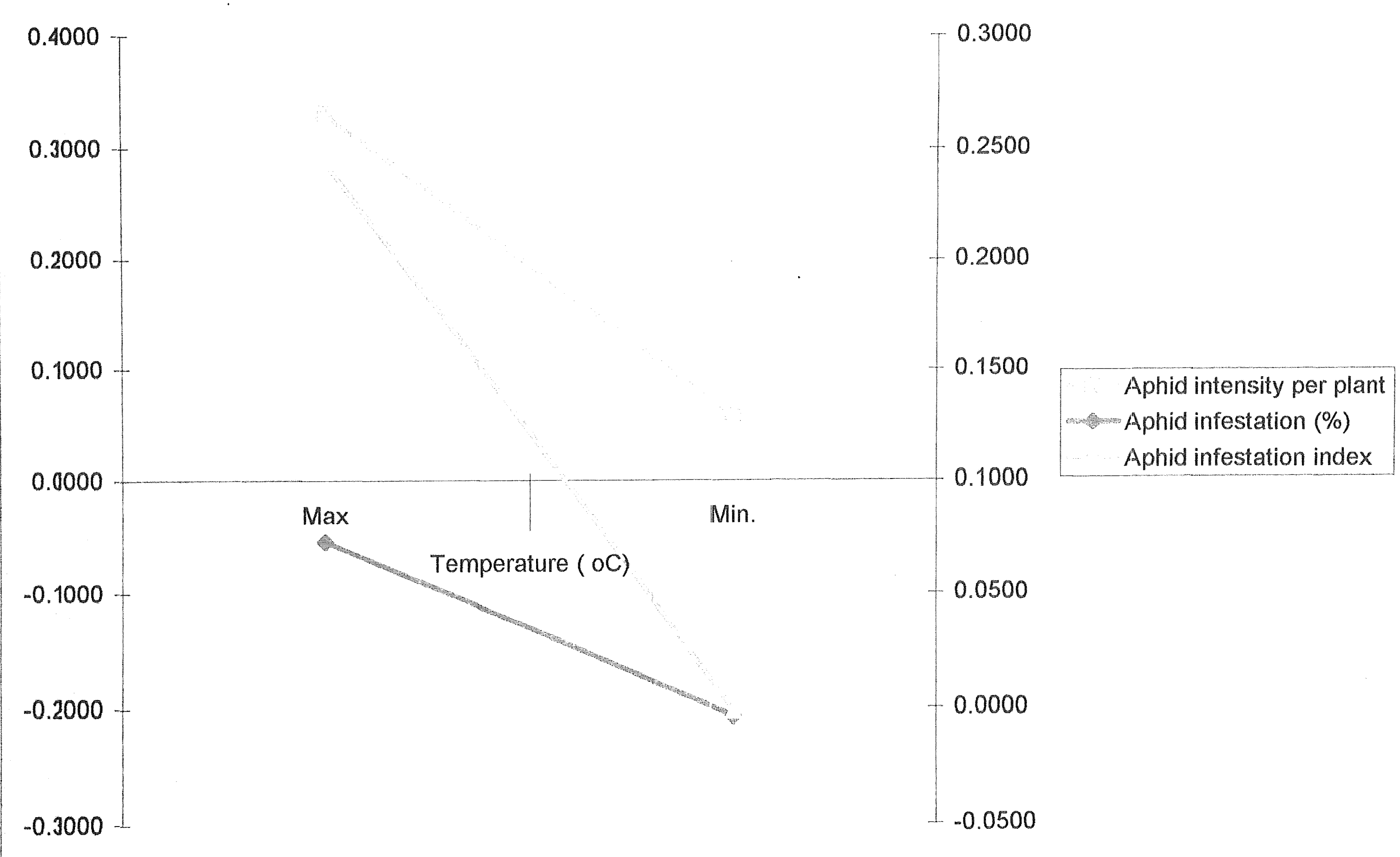
Fig 8. Seasonal abundance of mustard aphid for variety Vardan during 2005.

TABLE - 10

Simple correlation coefficient of aphid population with environmental factors for variety Varuna during 2004.

Parameters		Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
Temperature (°C)	Max	0.3313	-0.0543	0.2438
	Min.	0.0570	-0.2070	-0.0012
Relative humidity (%)	Morning	0.0658	0.4625	0.1526
	Evening	-0.1784	0.1296	-0.1066
Wind speed	(Km/hr)	0.0332	0.3353	0.0725
Evaporation rate	(mm/day)	0.2797	-0.3279	0.1471
Age of the crop		0.0406	0.3586	0.2602

Fig 9. Effect of temperature on aphid intensity,infestation and indices for Varuna during 2004



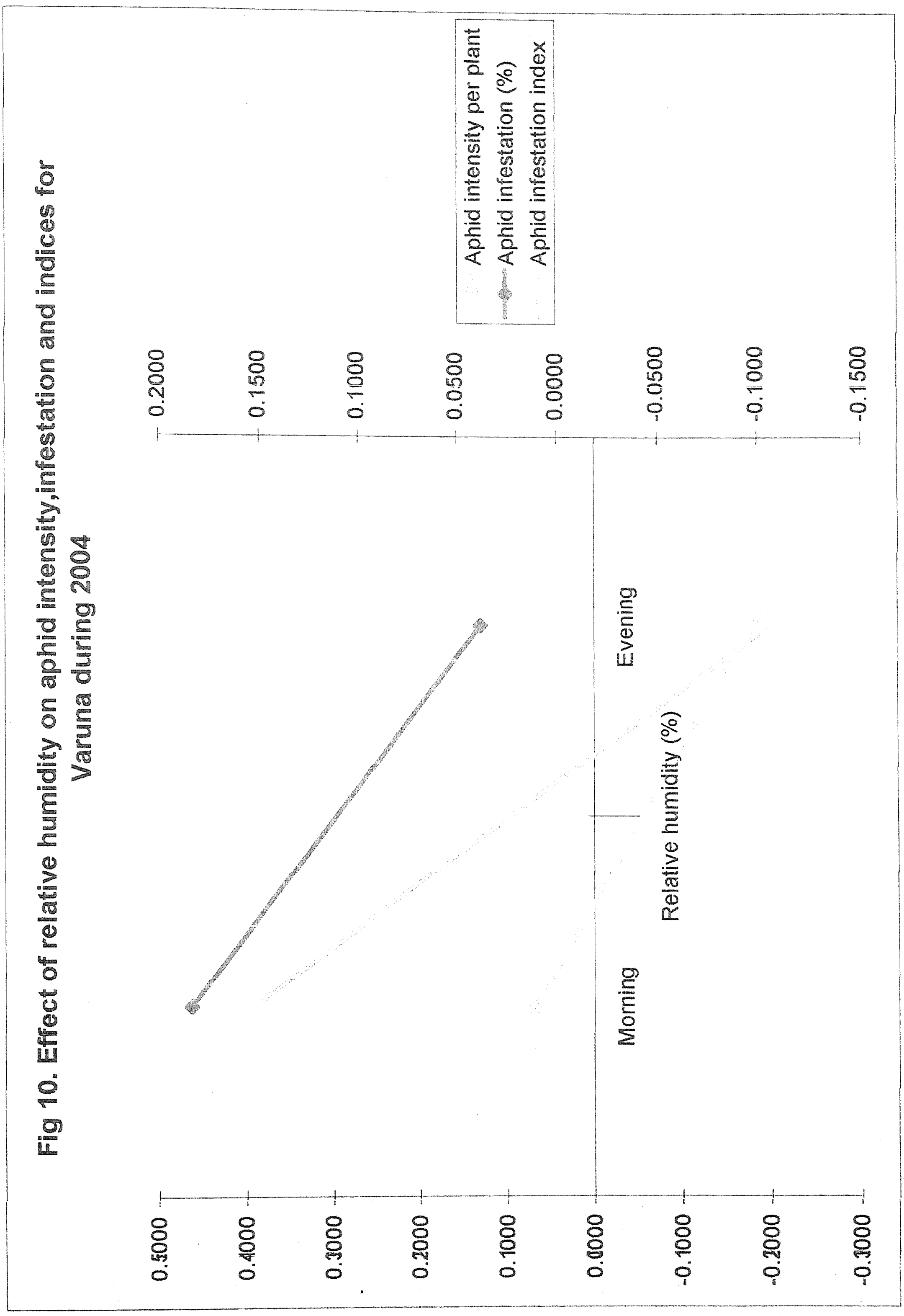


Fig 10. Effect of relative humidity on aphid intensity,infestation and indices for Varuna during 2004

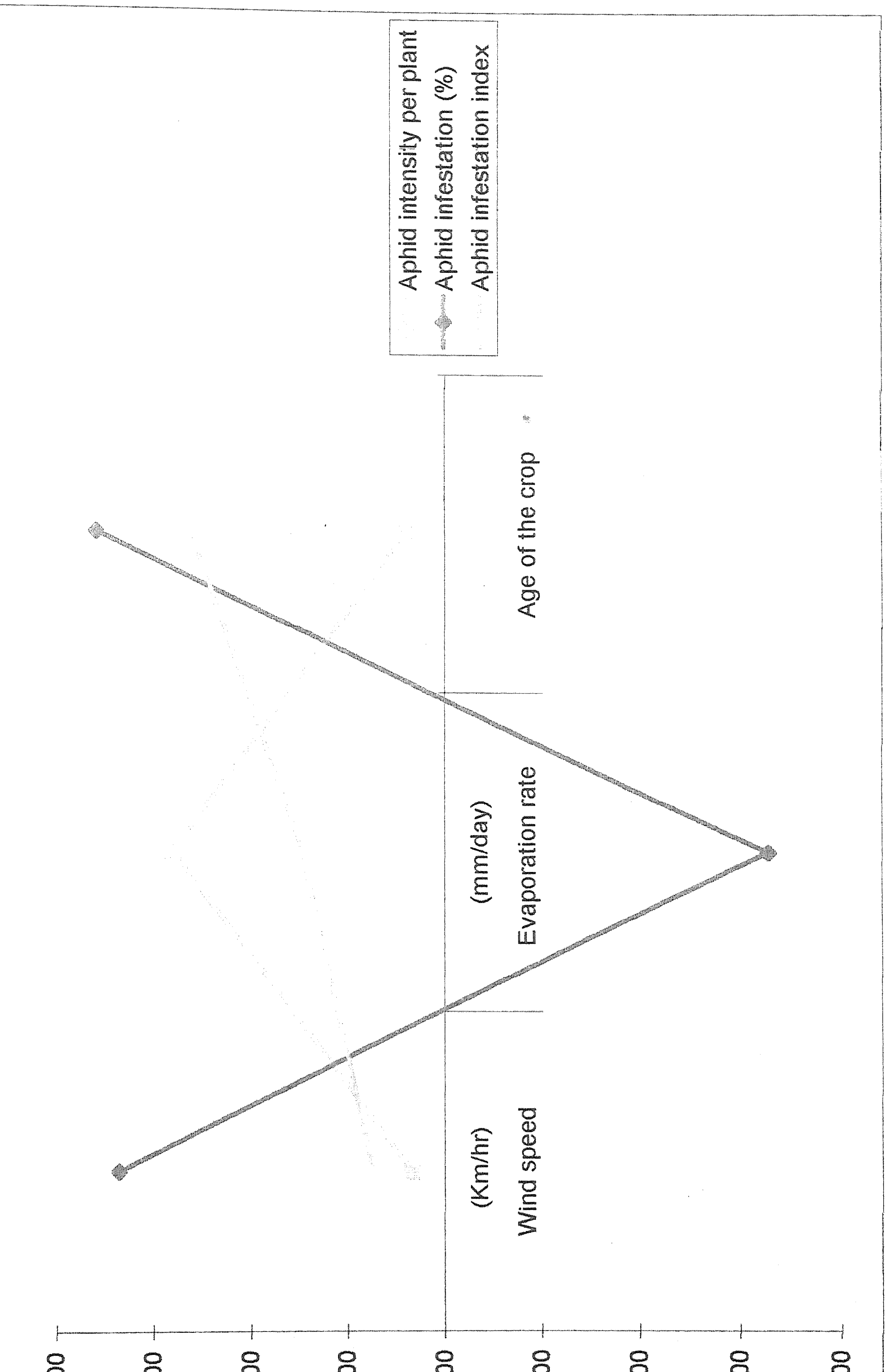


Fig 11. Effect of wind speed, evaporation rate and age of crop on aphid intensity,infestation and indices for Varuna during 2004

TABLE - 11

Simple correlation coefficient of aphid population with environmental factors for variety Rohini during 2004.

Parameters		Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
Temperature (°C)	Max	0.2480	-0.1184	0.3485
	Min.	-0.3300	-0.2067	0.0802
Relative humidity (%)	Morning	0.1396	0.5089	0.1149
	Evening	-0.1547	0.1949	-0.1597
Wind speed	(Km/hr)	-0.0164	0.4454	0.1499
Evaporation rate	(mm/day)	0.2381	-0.4048	0.1592
Age of the crop		0.3088	-0.4079	0.2009

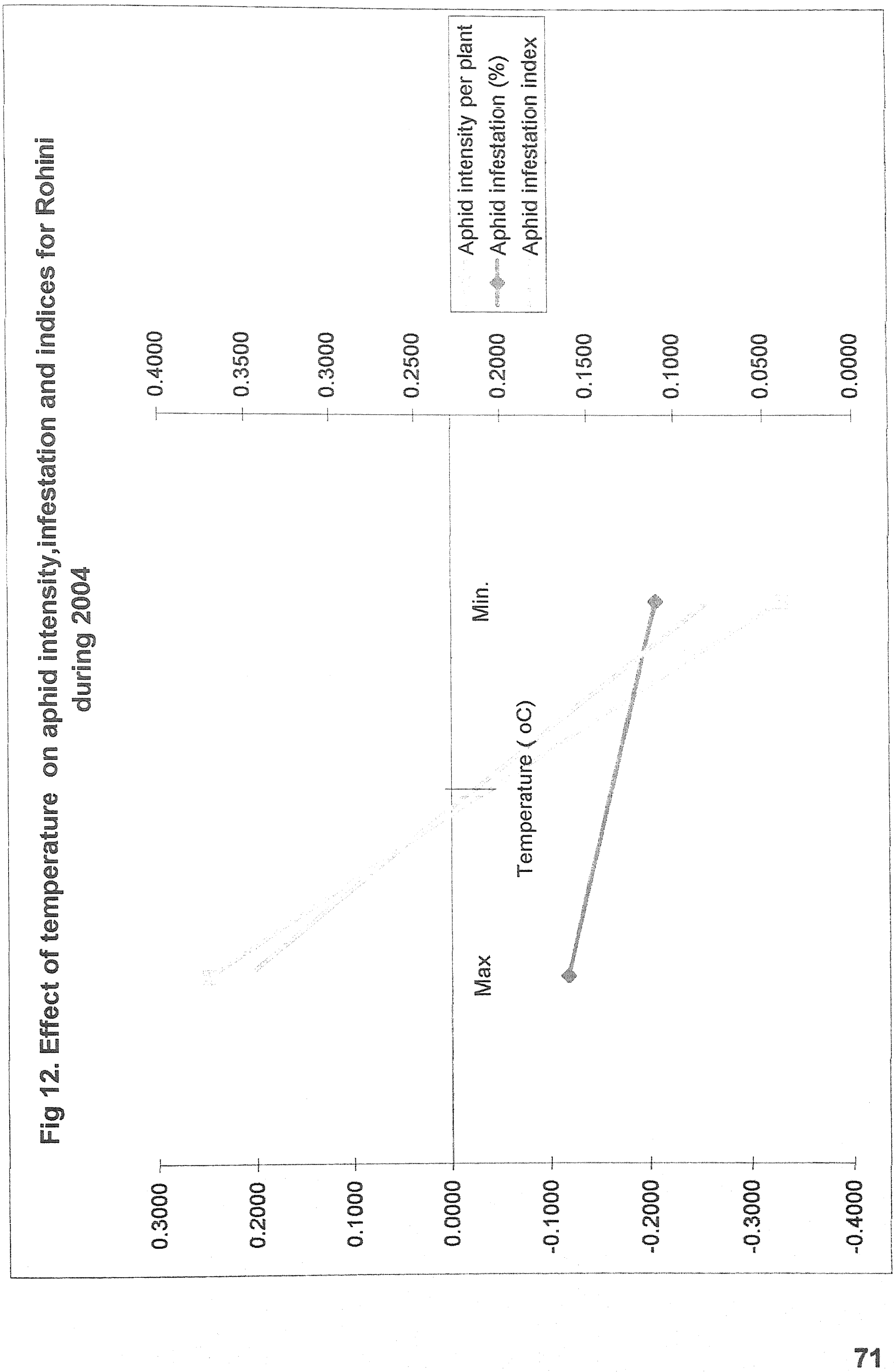


Fig 12. Effect of temperature on aphid intensity,infestation and indices for Rohini during 2004

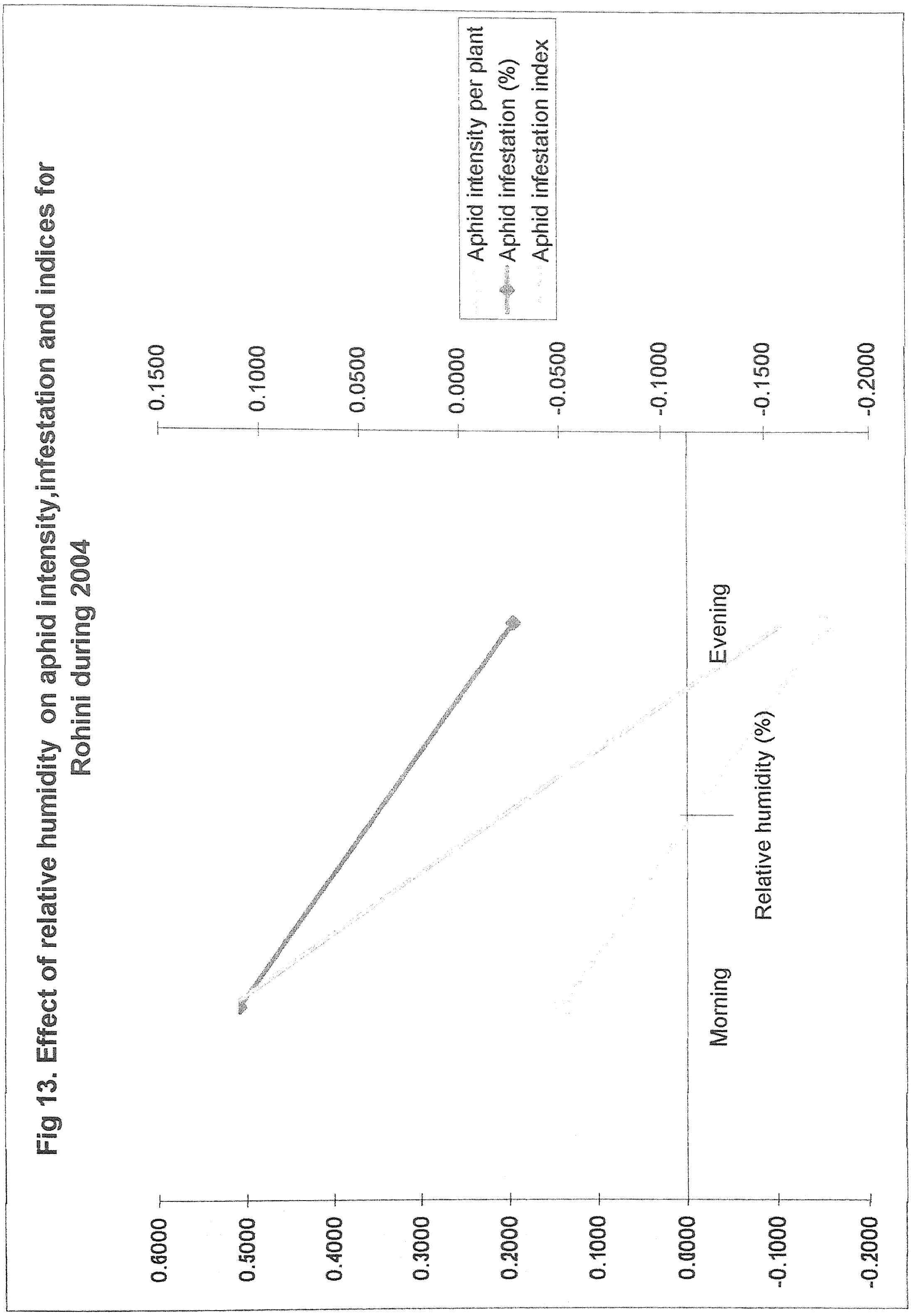


Fig 13. Effect of relative humidity on aphid intensity,infestation and indices for Rohini during 2004

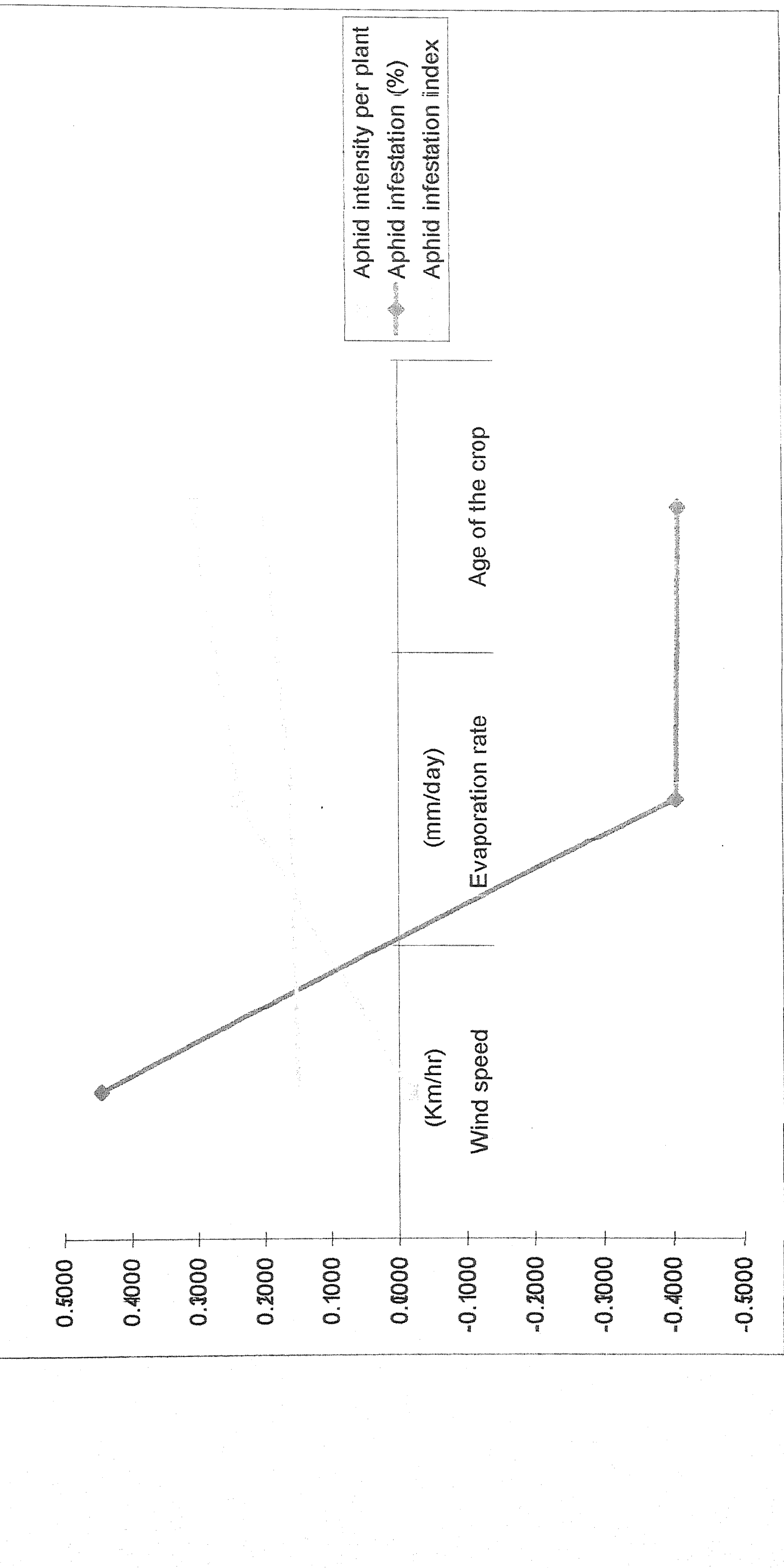


Fig 14. Effect of wind speed, evaporation rate and age of crop on aphid intensity,infestation and indices for Rohini during 2004

TABLE - 12

Simple correlation coefficient of aphid population with environmental factors for variety Vardan during 2004.

Parameters		Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
Temperature (°C)	Max	0.4439	-0.1091	0.3397
	Min.	0.1959	0.2079	0.0809
Relative humidity (%)	Morning	0.0268	0.5038	0.1225
	Evening	-0.2288	0.1879	-0.1473
Wind speed	(Km/hr)	0.2345	0.4081	0.1161
Evaporation rate	(mm/day)	0.2903	-0.4079	0.1580
Age of the crop		0.3303	-0.4349	0.2028

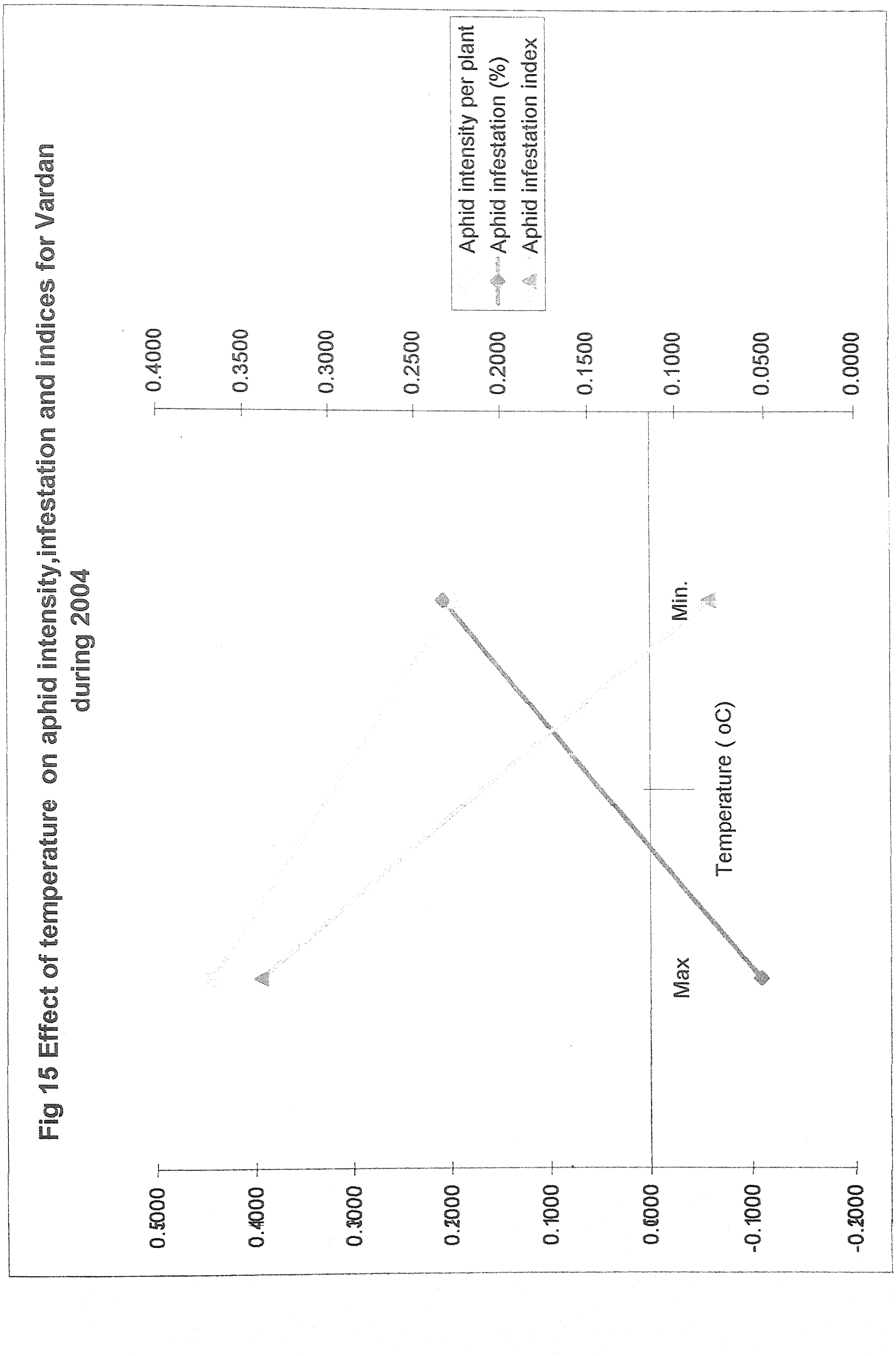


Fig 15 Effect of temperature on aphid intensity,infestation and indices for Vardan during 2004

Fig 16. Effect of Relative humidity on aphid intensity,infestation and indices for Vardan during 2004

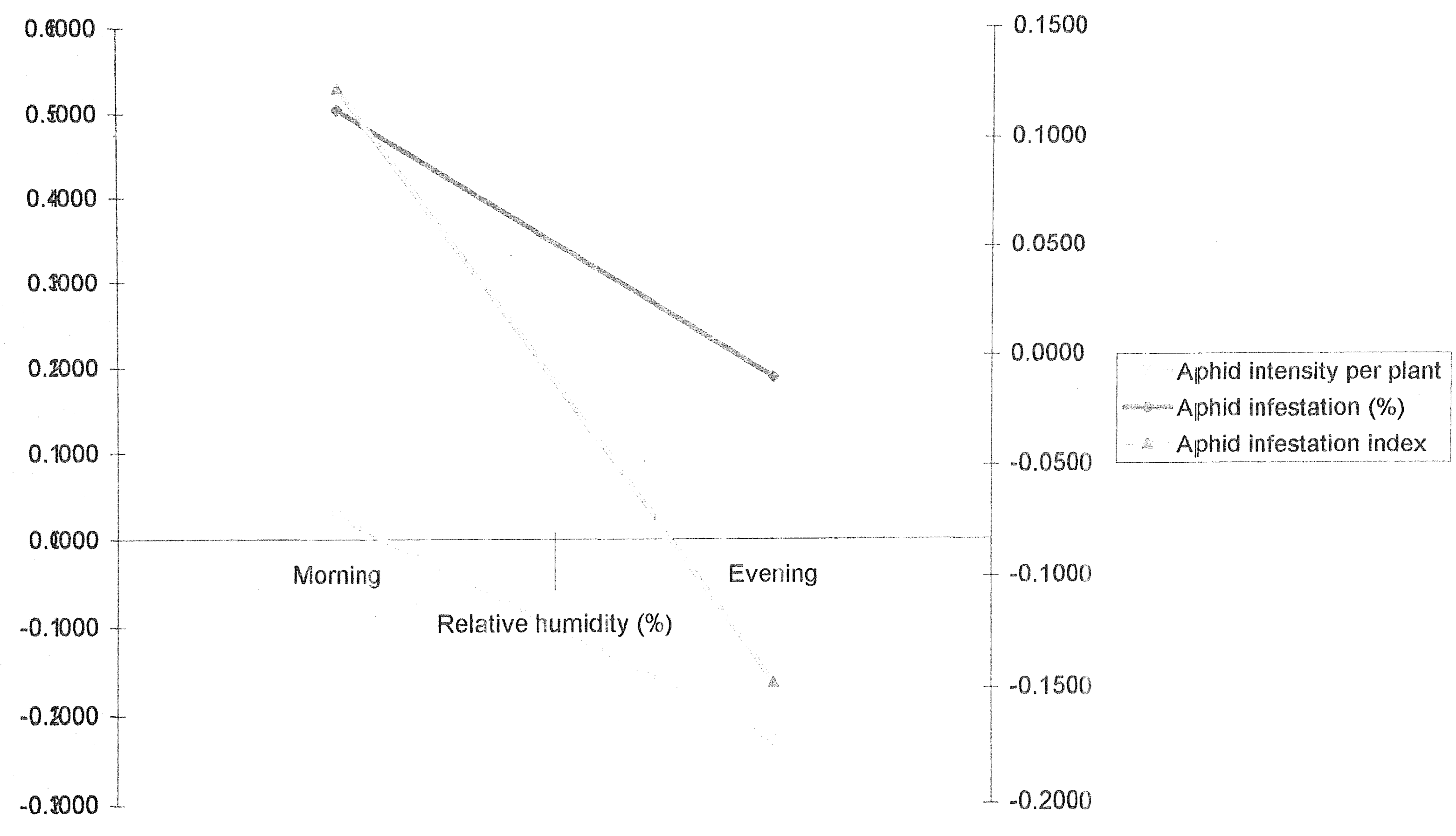


Fig 17. Effect of Wind speed,evaporation rate and age of crop on aphid intensity,infestation and indices for Vardan during 2004

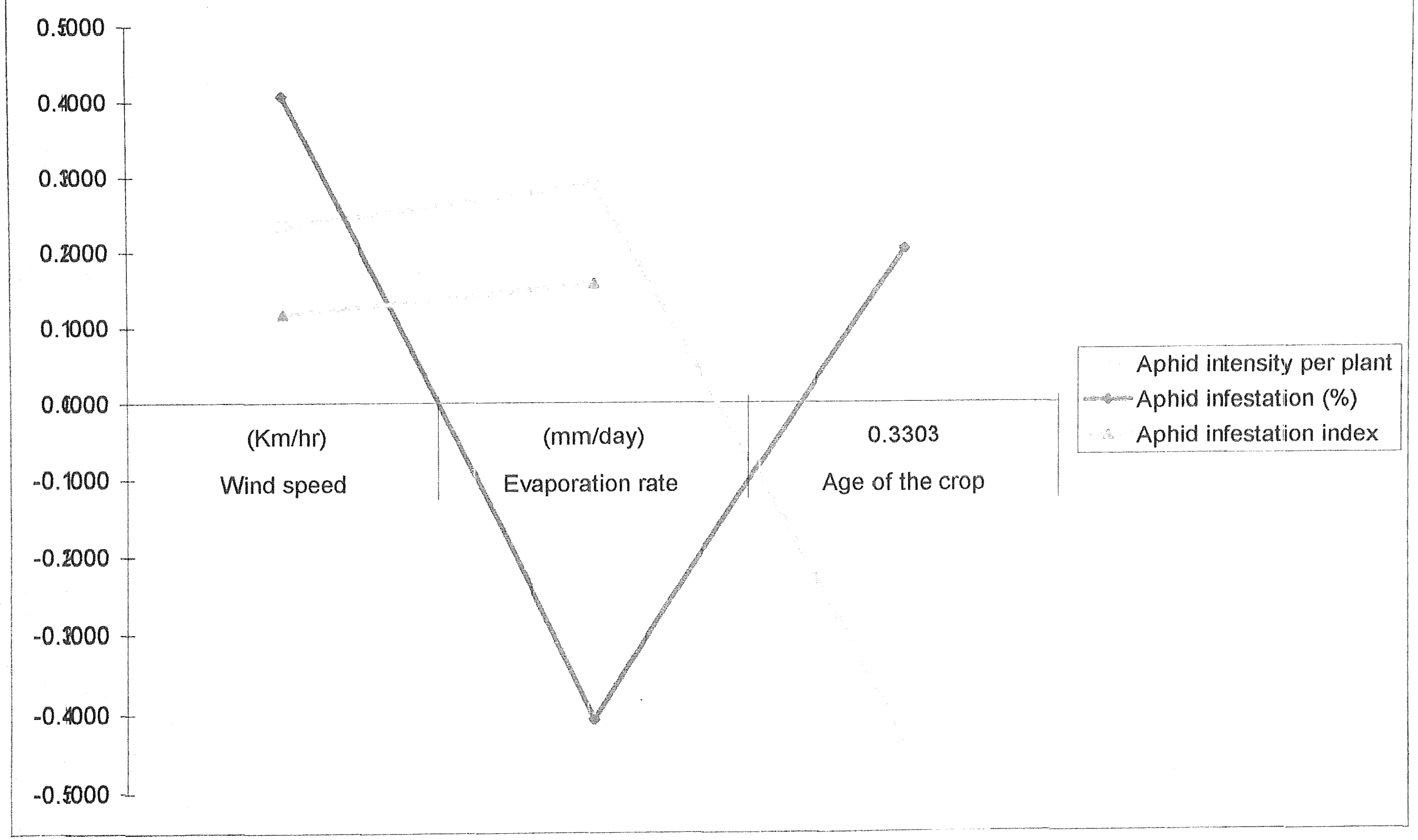


TABLE - 13

Simple correlation coefficient of aphid population with environmental factors for variety Varuna during 2005.

Parameters		Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
Temperature (°C)	Max	0.4258	-0.2779	0.1258
	Min.	0.0697	-0.6521	-0.3283
Relative humidity (%)	Morning	-0.6465	0.2867	-0.1731
	Evening	-0.8244*	-0.3662	-0.7101
Wind speed	(Km/hr)	-0.2695	0.5786	0.3303
Evaporation rate	(mm/day)	0.4924	-0.4283	0.0021
Age of the crop		0.3037	-0.5640	-0.1538

* Significant at 5% level.

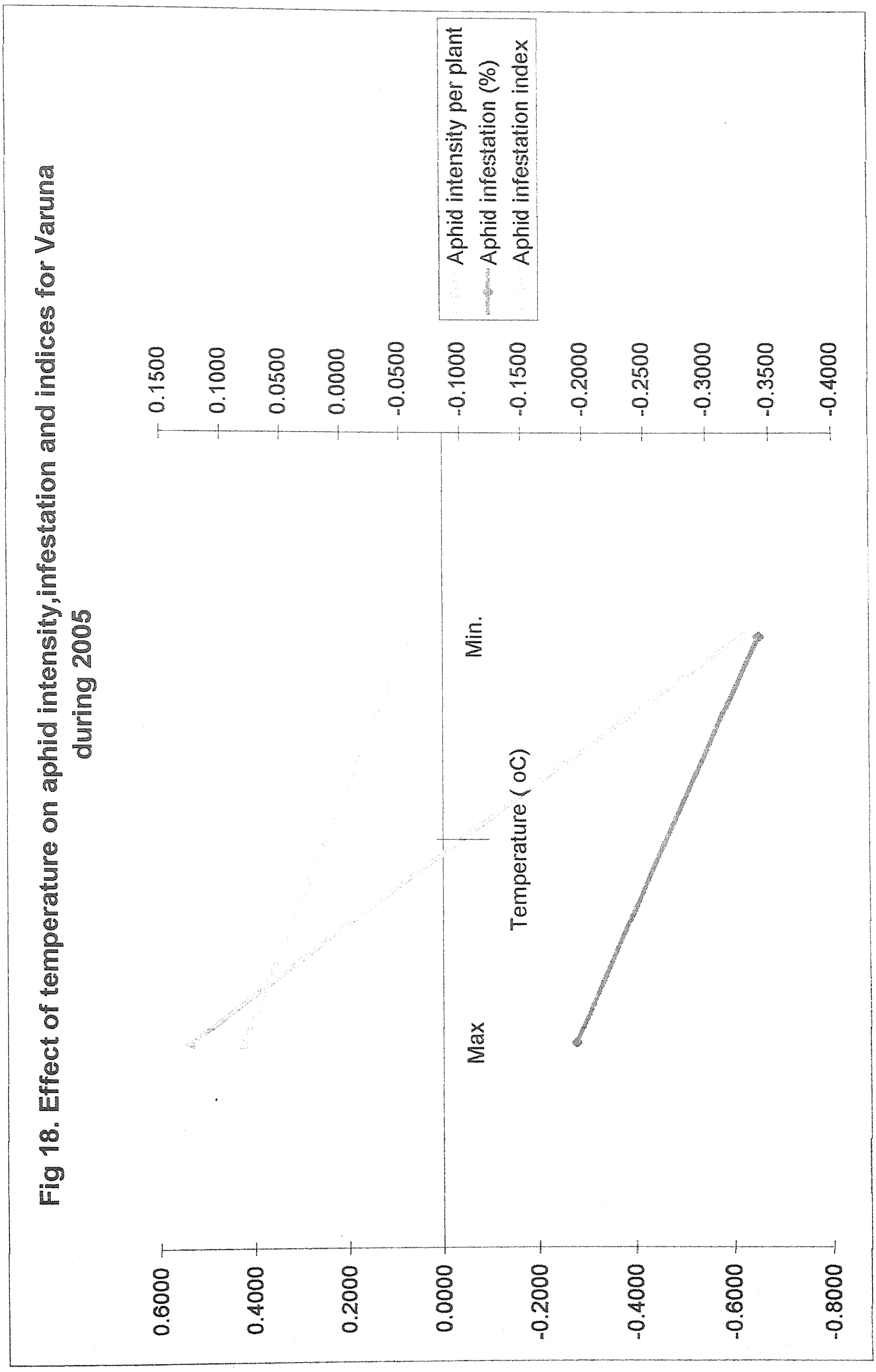


Fig 18. Effect of temperature on aphid intensity,infestation and indices for Varuna during 2005

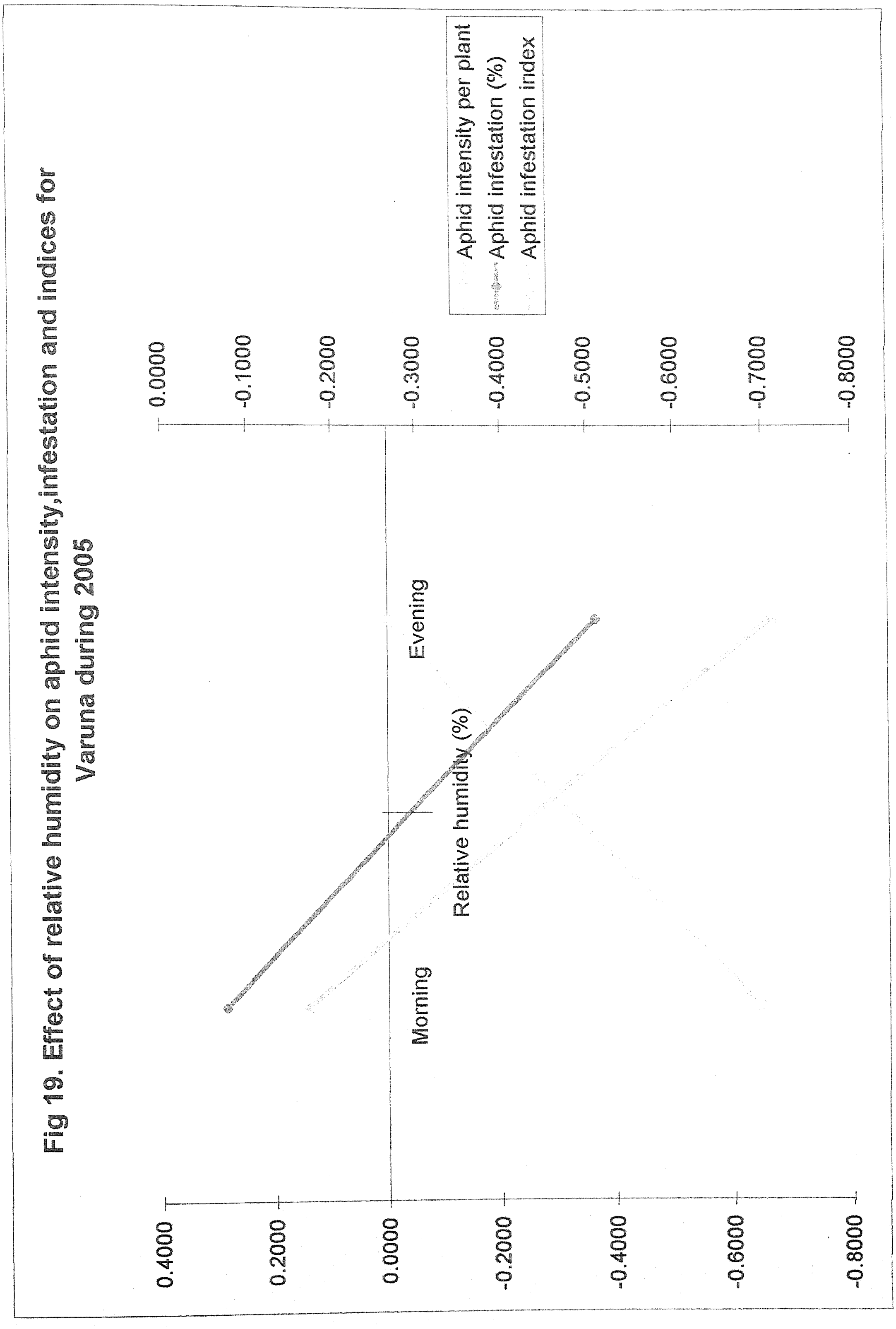
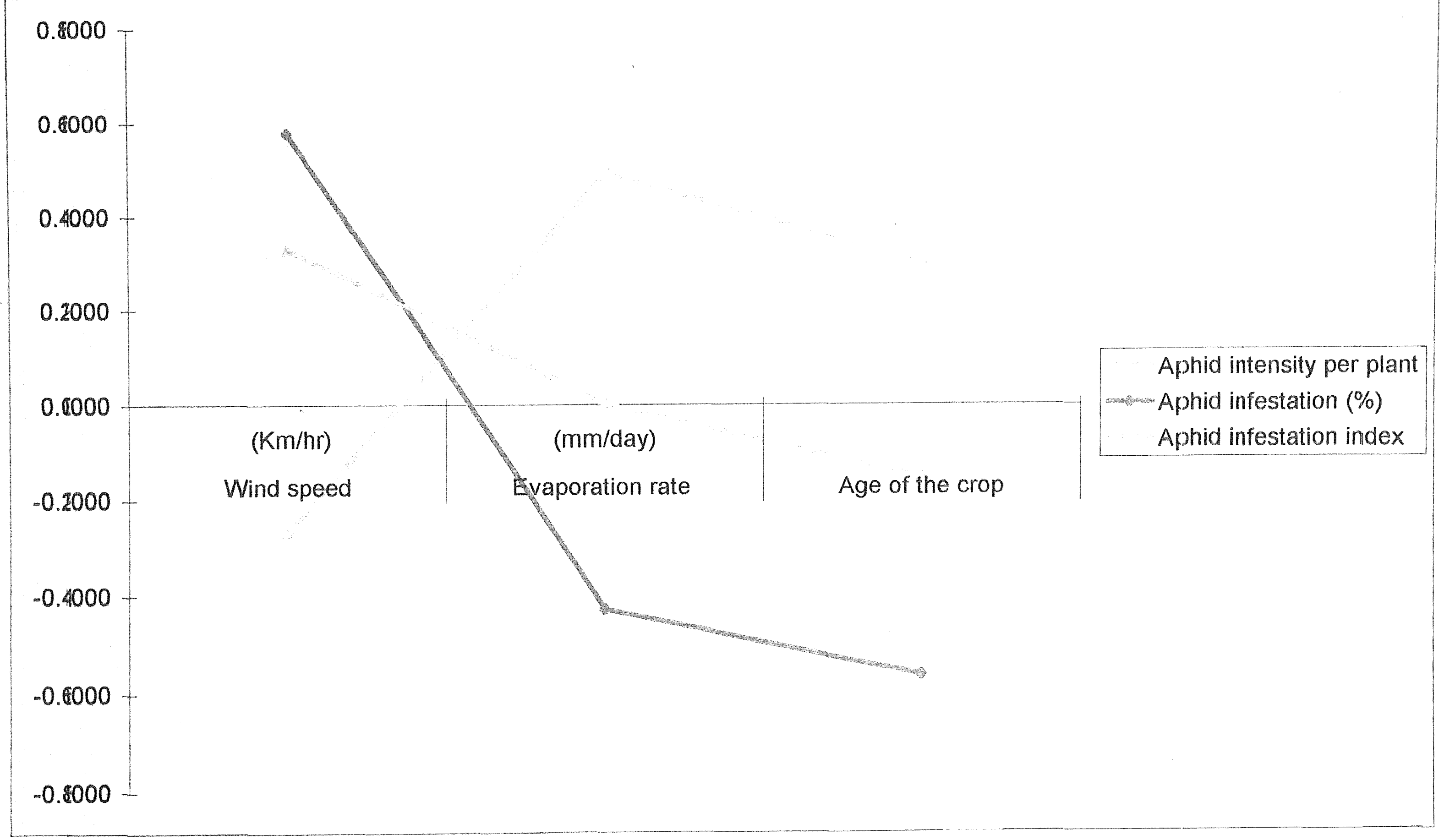


Fig 19. Effect of relative humidity on aphid intensity,infestation and indices for Varuna during 2005
0.4000
0.2000
0.0000
-0.2000
-0.4000
-0.6000
-0.8000
0.0000
-0.1000
-0.2000
-0.3000
-0.4000
-0.5000
-0.6000
-0.7000
-0.8000
Morning
Evening
Relative humidity (%)
Aphid intensity per plant
Aphid infestation (%)
Aphid infestation index

Fig 20. Effect of wind speed, evaporation rate and age of crop on aphid intensity,infestation and indices for Varuna during 2005



The simple analysis of the data of aphid intensity with, prevailing environmental conditions indicated a positive association of the temperature , wind speed and evaporation rate , age of the crop and negative effect of relative humidity , but all these factors could not show significant pronounced effect during the first year possibly due to reduction in aphid population with the maturity of the crop, but in 2004-05 relative humidity and wind speed showed significantly negative response on aphid intensity , while the effect of temperature was similar to previous year, this might be due to continuously low level of relative humidity in the second fortnight of January and first fortnight of February when aphid multiplication was at its peak in this year

(II) APHID INFESTATION:

The data evidences that in beginning, aphid infestation was 53.33, 60.66 and 63.33 per cent during the first year (2004) and 40.00, 43.33 and 53.33 per cent during the second year (2005) on varieties Varuna, Vardan and Rohini, respectively and was on full swing in the first week of February and last week of January on all the varieties during respective years . Environmental conditions could not show any significant correlation ship during both the years . It might be due to increase in infestation with increase in the temperature in the beginning of January but abrupt increase in temperature above 23^{0}C and decrease in relative humidity below 75.71 per cent along with the increase in wind speed

TABLE - 14

Simple correlation coefficient of aphid population with environmental factors for variety Rohini during 2005.

Parameters		Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
Temperature (°C)	Max	0.4409	-0.3432	0.1098
	Min.	0.1008	-0.6765	-0.3469
Relative humidity (%)	Morning	-0.6478	0.3375	-0.1697
	Evening	-0.8141*	-0.2974	-0.6675
Wind speed	(Km/hr)	-0.2814	0.5332	0.3669
Evaporation rate	(mm/day)	0.4988	-0.4710	-0.0060
Age of the crop		0.3140	-0.6232	-0.1714

* Significant at 5% level.

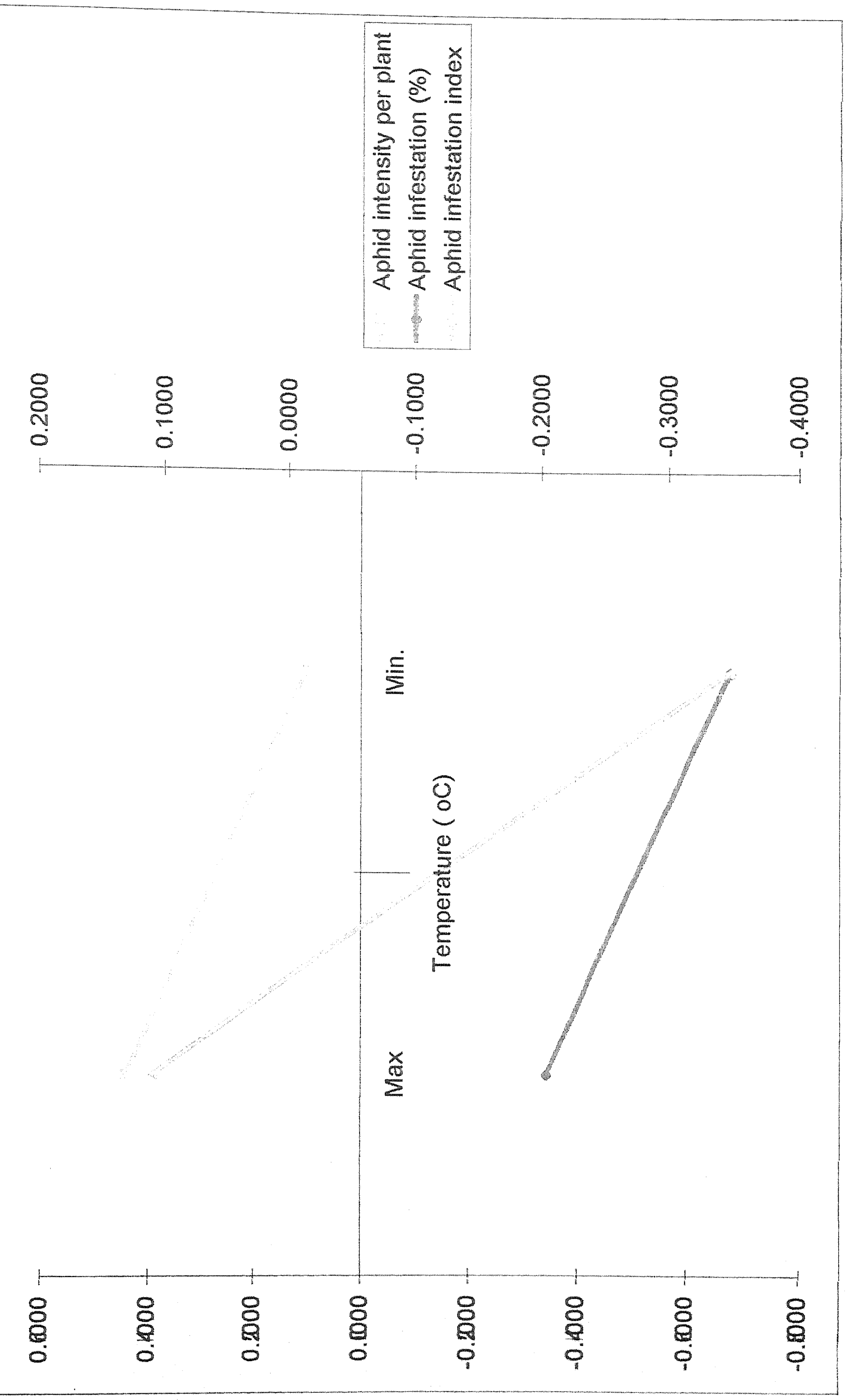
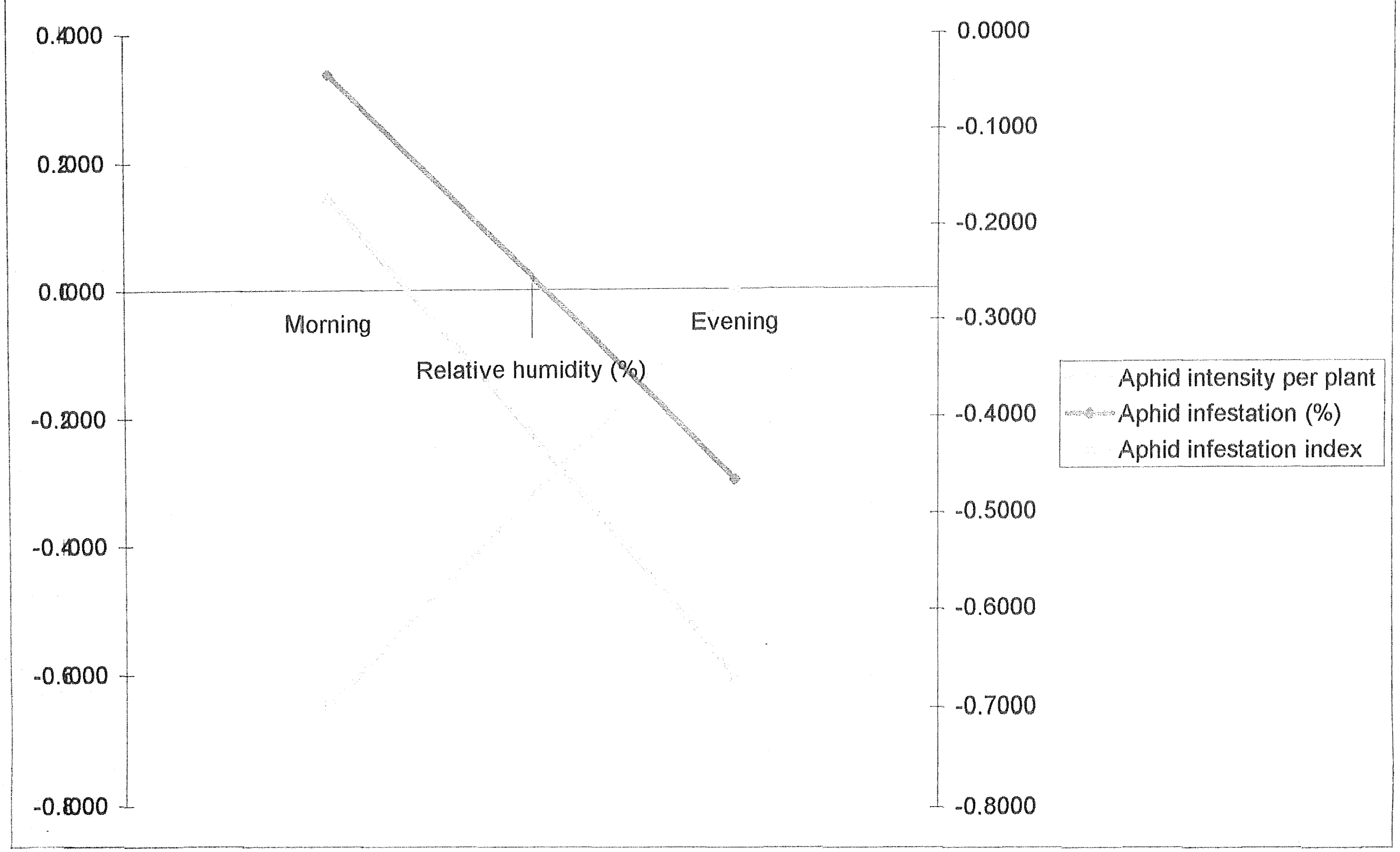


Fig 21. Effect of temperature on aphid intensity,infestation and indices for Rohini during 2005

Fig 22. Effect of relative humidity on aphid intensity,infestation and indices for Rohini during 2005



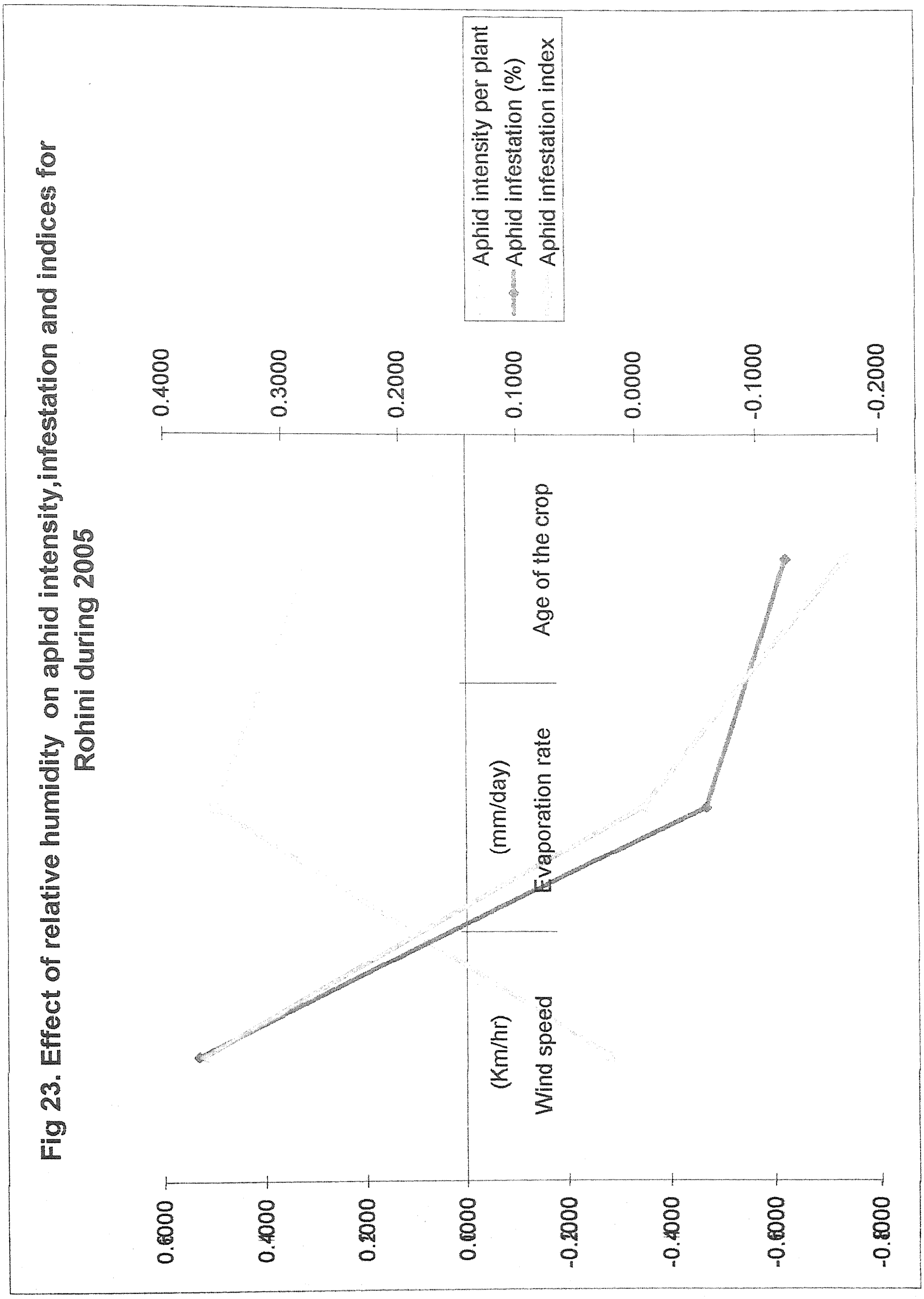


Fig 23. Effect of relative humidity on aphid intensity,infestation and indices for Rohini during 2005

TABLE - 15

Simple correlation coefficient of aphid population with environmental factors for variety Vardan during 2005.

Parameters		Aphid intensity per plant	Aphid infestation (%)	Aphid infestation index
Temperature (°C)	Max	0.4110	-0.2906	0.1349
	Min.	0.0746	-0.6344	-0.3249
Relative humidity (%)	Morning	-0.6162	0.3247	-0.1840
	Evening	-0.8531*	-0.2853	-0.3544
Wind speed	(Km/hr)	-0.3304	0.6213	0.3544
Evaporation rate	(mm/day)	-0.4453	-0.4482	0.0165
Age of the crop		0.3153	-0.5876	-0.1473

* Significant at 5% level.

Fig 24. Effect of temperature on aphid intensity,infestation and indices for Vardan during 2005

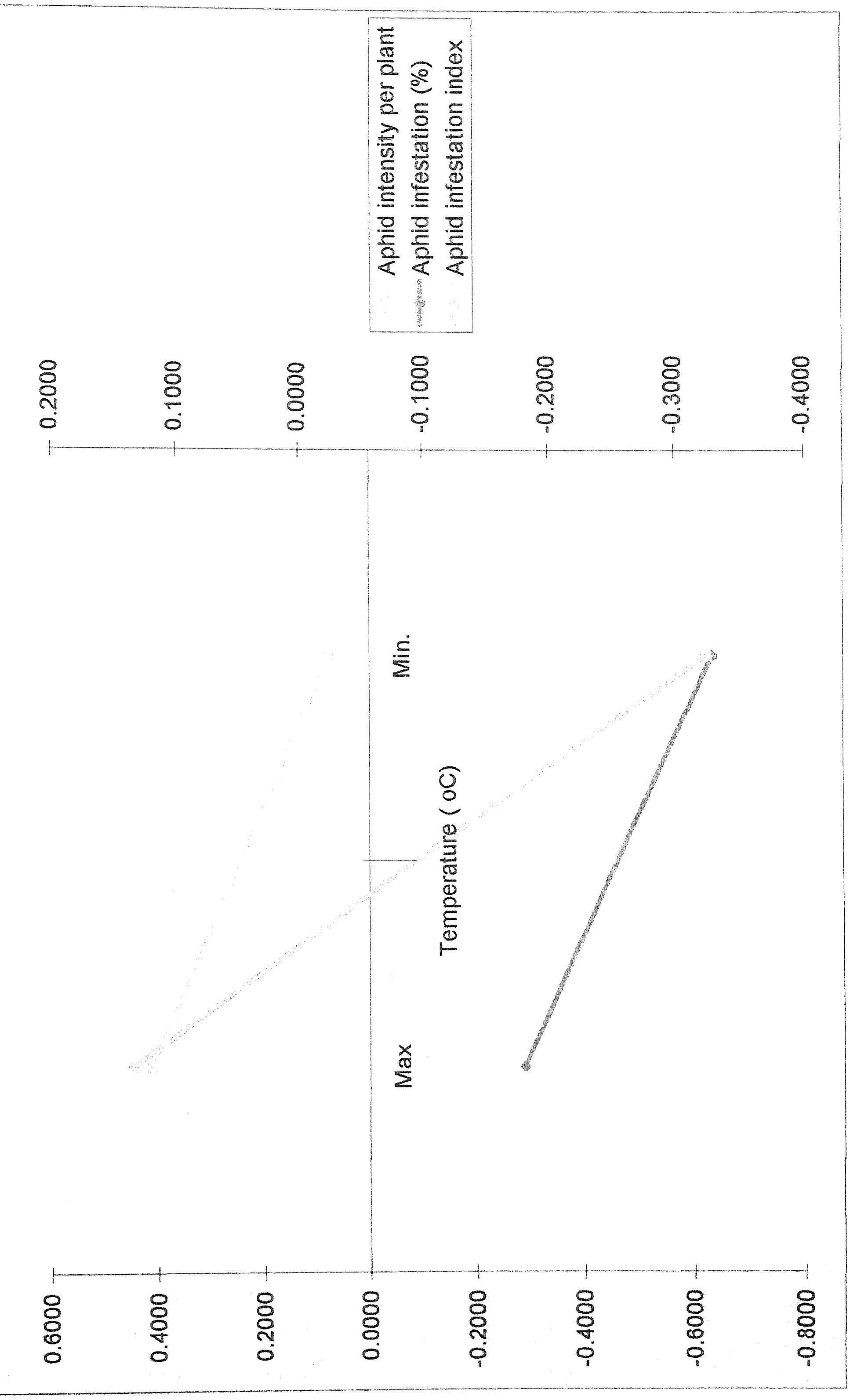


Fig 25. Effect of Relative humidity on aphid intensity,infestation and indices for Vardan during 2005

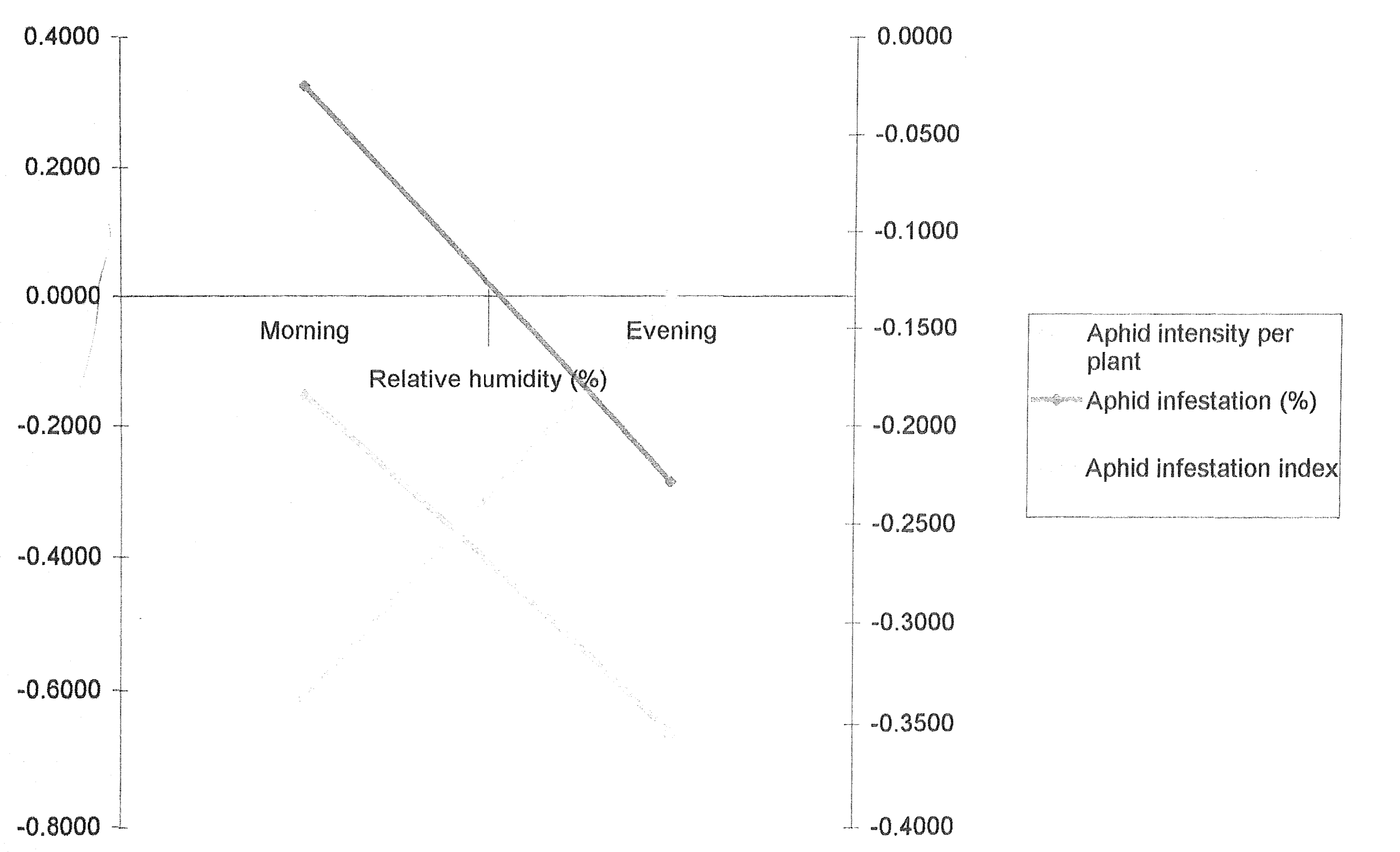
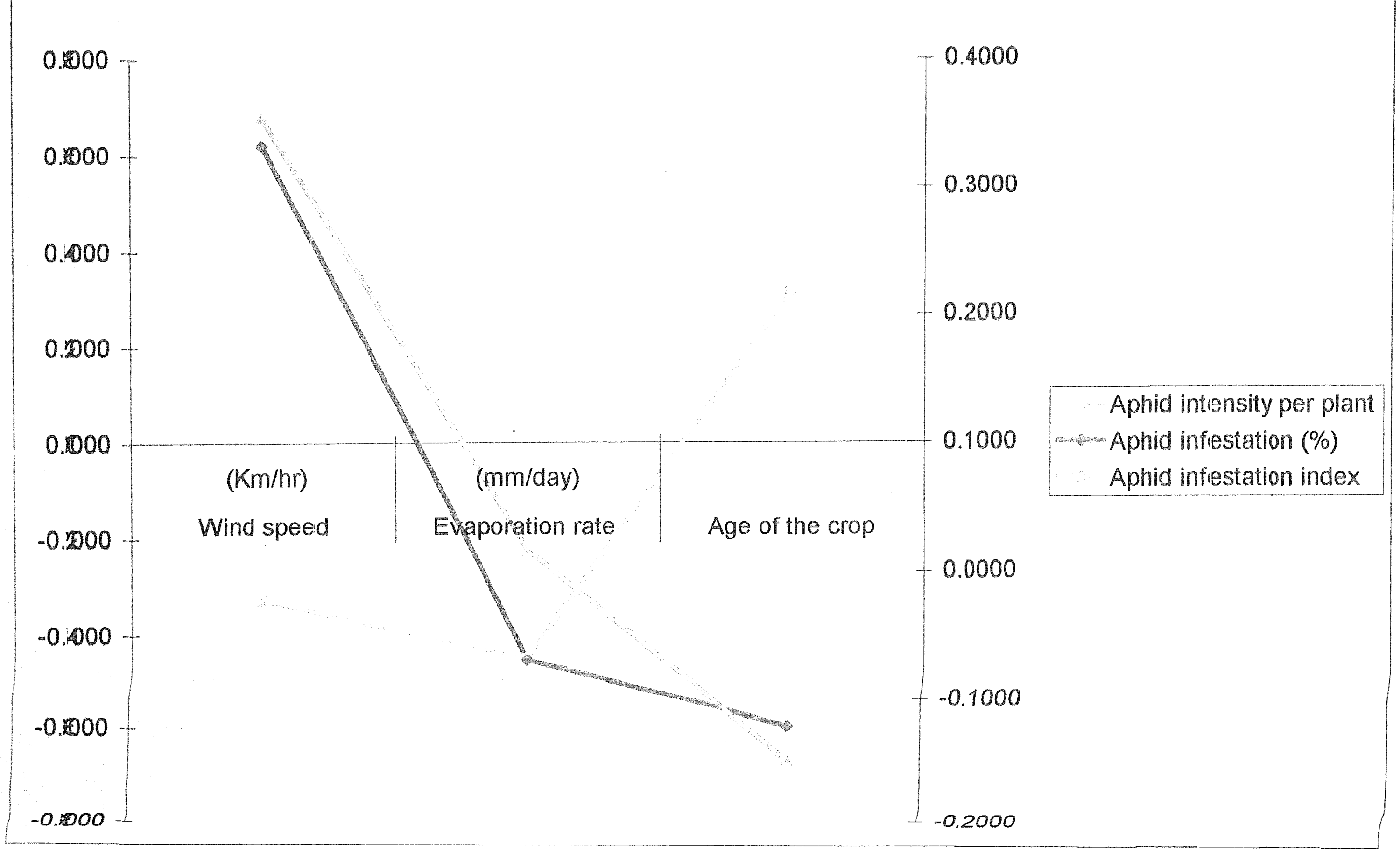


Fig 26. Effect of Wind speed,evaporation rate and age of crop on aphid intensity,infestation and indices for Vardan during 2005



more than 4 Km. / hr. in the end of January had shown detrimental effect on spread of aphid infestation. The complete elimination of aphid population during the end of February in the first year (2004), could be associated with more than 25.42^{0}C maximum and 11.14^{0}C minimum temperature associated with 72.42 per cent morning and 47.00 per cent evening relative humidity with 3.69 Km / hr wind speed ( ) in the third week of February. Meanwhile, identical environmental conditions prevailed during the second week of February in the second year ( ).

(III) Aphid Indices :

Aphid index was at a level of 0.60 on all the three varieties namely, Varuna, Rohini and Vardan during the 2004 and was at slightly low level of 0.43, 0.46 and 0.40 on respective varieties during 2005. The aphid index was found more associated with aphid infestation as it was at peak (3.16-3.33) in the first week of February in 2004 and in the last week of January (2.00-2.33) in the 2005 and reached to zero level in the end of February and by 20th February in the respective years with the wipe out of aphid population. As regard the impact of environmental factors, it was similar to those explained in case of aphid infestation indices).

The appearance of 2.0 and 1.33 aphids per plant with an infestation level of 53.33 per cent on Vardan showing their indices at 0.60 and 0.46 on all of them in third week of January when maximum

TABLE - 16

Population of Coccinellids on variety Varuna during 2004.

Date of observation		Age of the crop (days)	Adult	Grub
January	17	66	0	0
	24	73	0	0
	31	80	0	0
February	7	87	0	0
	14	94	0	0
	21	101	1	0
	28	108	3	0
March	7	115	4	5
	14	122	5	15

Fig. 27 Population of Coccinellids on variety Varuna during 2004.

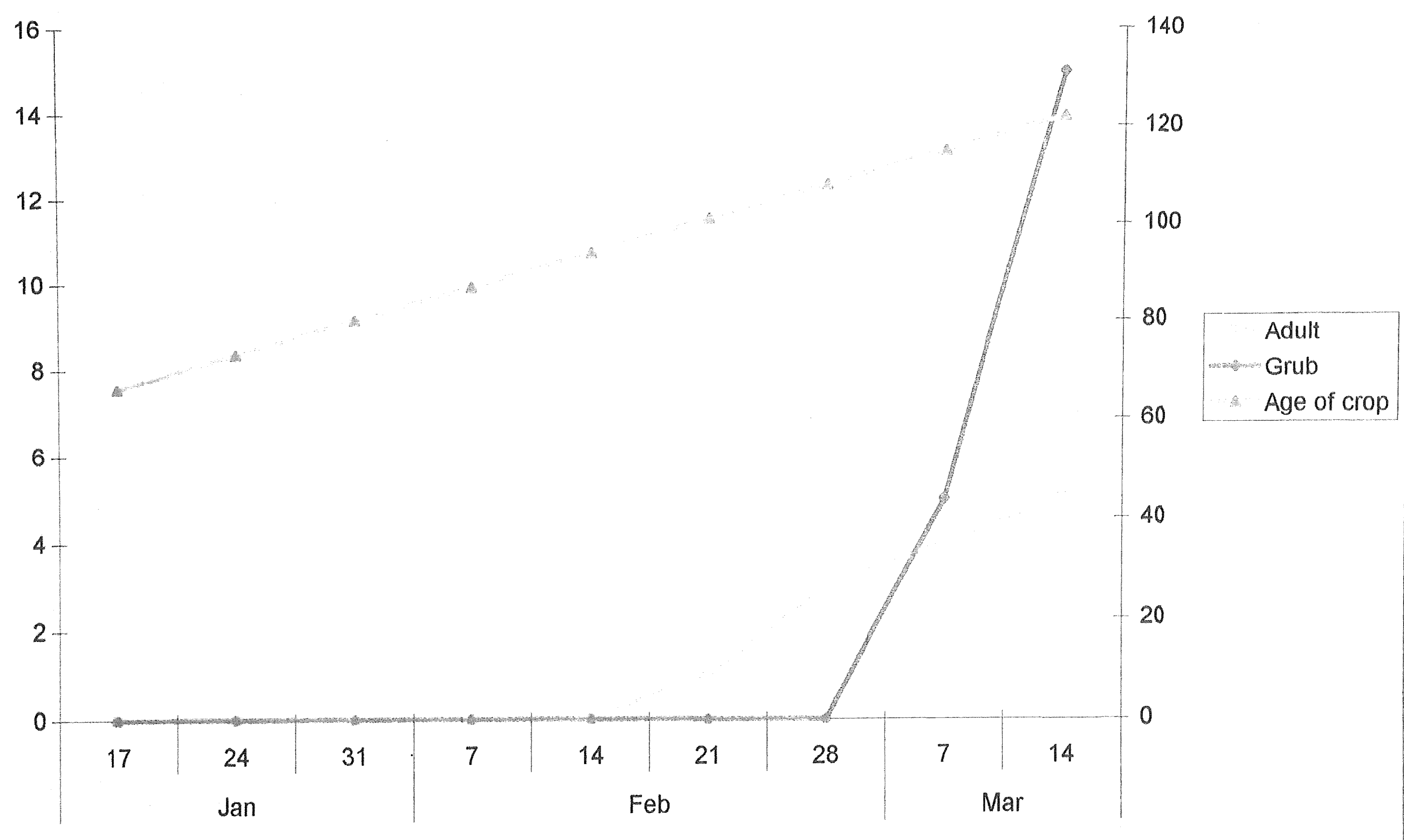


TABLE - 17

Population of Coccinellids on variety Rohini during 2004.

Date of observation		Age of the crop (days)	Adult	Grub
January	17	66	0	0
	24	73	0	0
	31	80	0	0
February	7	87	0	0
	14	94	0	0
	21	101	0	0
	28	108	4	0
March	7	115	4	7
	14	122	5	16

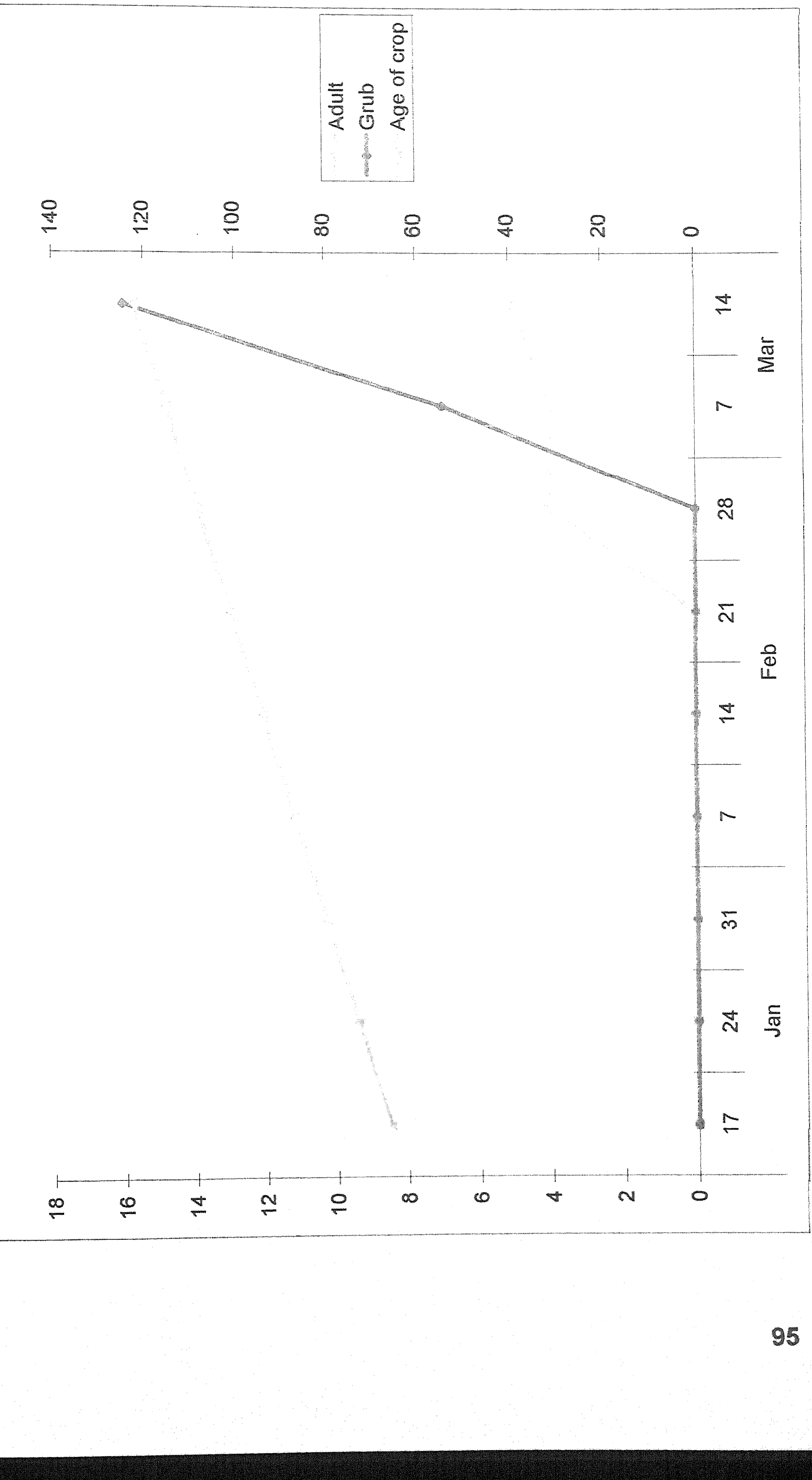


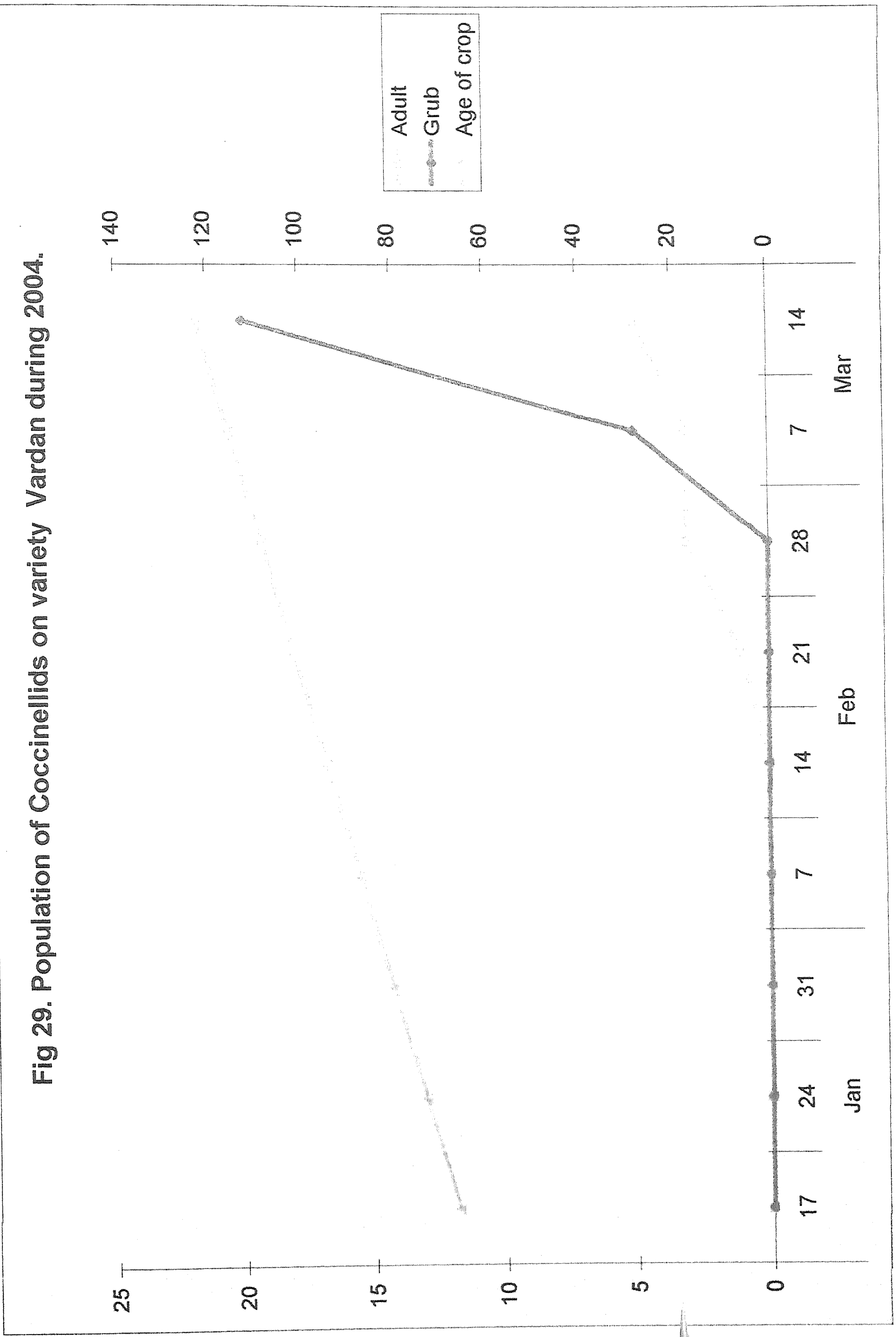
Fig 28. Population of Coccinellids on variety Rohini during 2004.

TABLE - 18

Population of Coccinellids on variety Vardan during 2004.

Date of observation		Age of the crop (days)	Adult	Grub
January	17	66	0	0
	24	73	0	0
	31	80	0	0
February	7	87	0	0
	14	94	0	0
	21	101	1	0
	28	108	3	0
March	7	115	3	5
	14	122	5	20

Fig 29. Population of Coccinellids on variety Vardan during 2004.



temperature was 19.97 or 20^{0}C and relative humidity more than 90.14 or 90.0 per cent along with low evaporation rate 1 mm/day during both the years. There was an increase to a full swing of 403.00 and 264.33 aphid per plant on Varuna; 391.66 and 1.66 on Rohini and 358.33 and 268.33 on Vardan in respective years. The infestation indices were ranging from 3.16-3.33 in previous year and 2.00-2.33 during second year in the first fortnight of February when temperature was ranging from 22.00-27.4^{0}C (Maximum) and 9.42-11. 97^{0}C (minimum) with reduction in relative humidity 60.50-70.42 per cent. Regarding appearance of aphid during January, these findings are in accordance with those of [illegible] who also noticed appearance of aphid population during January. [illegible] reported most vulnerable period of high population of aphid during second week of February and last week of February and they got negative correlation of the temperature and positive correlation of relative humidity in the initial rising phase and falling phase of aphid population. [illegible] noticed appearance of aphids during January in the flowering stage of the *Brassica juncea*. [illegible] also recorded *L. erysimi* on mustard in the Ist week of January at average temperature 14.12^{0}C coupled with 85 per cent relative humidity. On the other hand, Singh and Singh (1986) obtained maximum population during first week of January. Jaglan *et al.* (1988) are of the opinion that *L. erysimi* was at its peak from the end of

February to end of March and they found no influence of temperature and humidity on aphid population. The findings of [illegible] are in complete agreement with the present results, regarding effect of temperature being maximum 21.7-23.5^{0}C minimum 7.2-9.4^{0}C in January -February with relative humidity between 51.5 to 69.4 per cent in these months. The observation of [illegible] are in conformity with the present findings, regarding elimination of the aphid population in the last week of February and Ist week of March with a rise in temperature beyond 9.6^{0}C minimum and 25.6^{0}C maximum. [illegible] reported maximum development of aphids between the temperatures ranging from 16 to 23^{0}C. [illegible] are of the view that aphid appeared on mustard after 74 to 76 days of sowing and completely eliminated by the age of 86 to 94 days. According to [illegible], aphid appeared on mustard in the later part of vegetative stage and gradually decline with the flowering and fruiting stage. In the present findings, aphid prevailed upto 101 to 110 days stage of the crop irrespective of the varieties in the 2rd and 3nd week of February, when temperature exceeding the limits of 24.42^{0}C maximum and 10.28^{0}C minimum along with relative humidity 66.5 and 40.85 per cent in morning and evening with wind speed 3.69 Km/hr. in the succeeding week in the Ist year and a temperature of 27^{0}C maximum and 12.^{0}C minimum associated with 70 per cent relative humidity and 2.88 Km/hr wind speed continuously

from the middle of February during 2nd year, had become inconducive for aphid multiplication. Regarding the non-significant effect of temperature and humidity on aphid intensity, infestation and indices, the present findings are being supported by those of [illegible], who reported no significant influence of temperature and humidity on mustard variety Prakash and also got the full support from [illegible] regarding the effect of temperature and wind speed in migration of aphid. Thus, it can be concluded that aphid appeared in the flowering stage of the crop at 55-82 days after sowing in the middle of January. In the beginning 1.33 and 2.80 aphids per plant were observed with an infestation level of 53.33-63.33 per cent at an index of 0.46-0.60 and reached at its peak in the middle of February and eliminated during 3rd and 4th week of February from mustard crop.

2. NATURAL ENEMIES:

The perusal of Table ([illegible]) indicate that a mixed population of coccinellied predators namely, *chilomenes (Menochillus). Sexmaculata* Fabr ; *Coccinella septempuntata* Linn; *Coccinella repands* Thunberg. etc, of February during 2004-2005, when the crop was more than 101 days old. The population of the adults was more in the commencement of the March during both the years when 15 to 20 and 10 to 12 grubs per plant were recorded against 2-5 adults during respective year. It is very interesting to know that the appearance of Coccinellieds was associated with the elimination of the aphids and they may be considered, as an important effectiveness of Coccinellied

TABLE - 19

Population of Coccinellids on variety Varuna during 2005.

Date of observation		Age of the crop (days)	Adult	Grub
January	16	82	0	0
	23	89	0	0
	30	96	0	0
February	6	103	0	0
	13	110	1	0
	20	117	3	0
	27	124	4	3
March	6	131	4	10

Fig 30. Population of Coccinellids on variety Varuna during 2005.

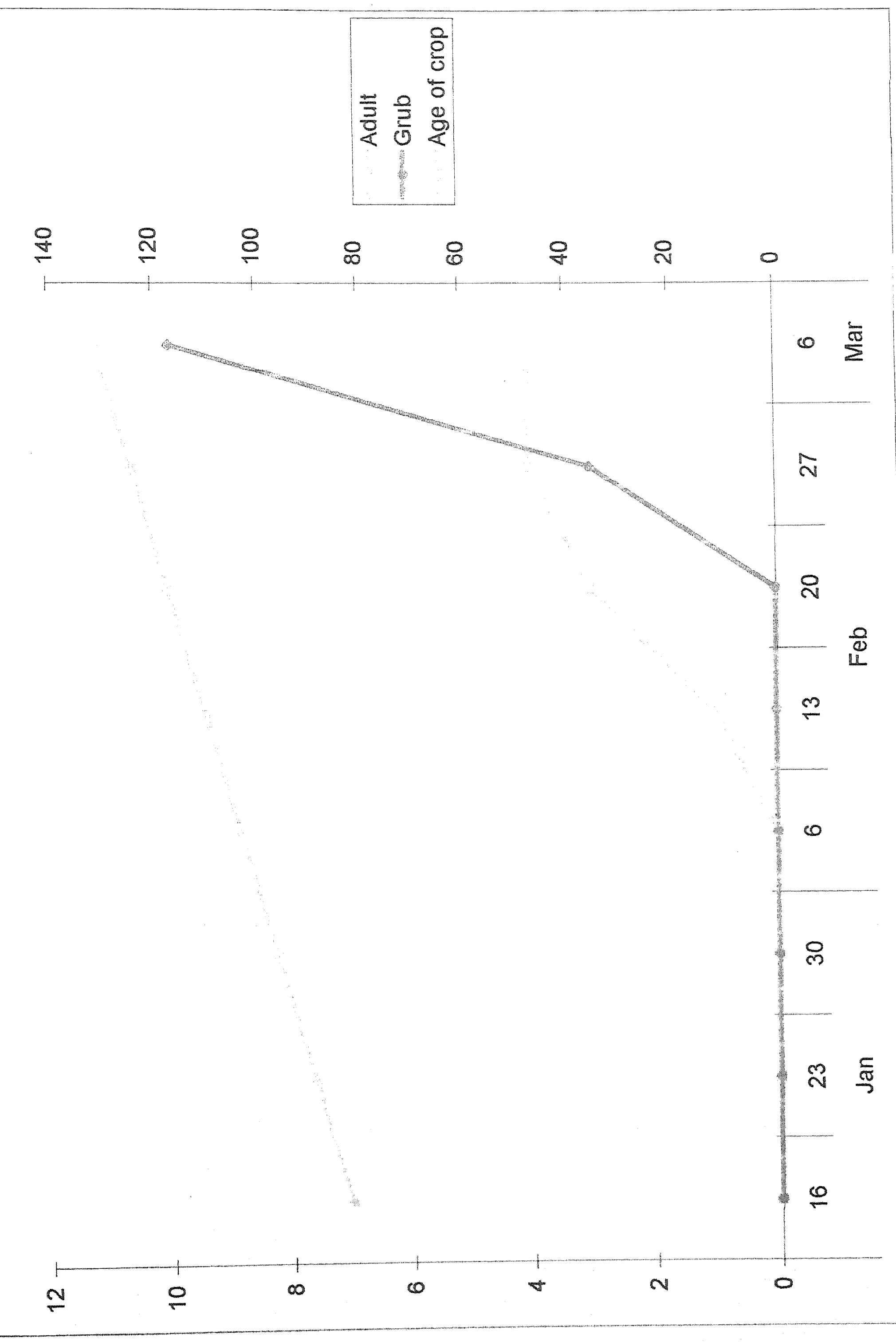


TABLE - 20

Population of Coccinellids on variety Rohini during 2005.

Date of observation		Age of the crop (days)	Adult	Grub
January	16	82	0	0
	23	89	0	0
	30	96	0	0
February	6	103	0	0
	13	110	1	0
	20	117	3	0
	27	124	3	4
March	6	131	2	12

Fig 31. Population of Coccinellids on variety Rohini during 2005.

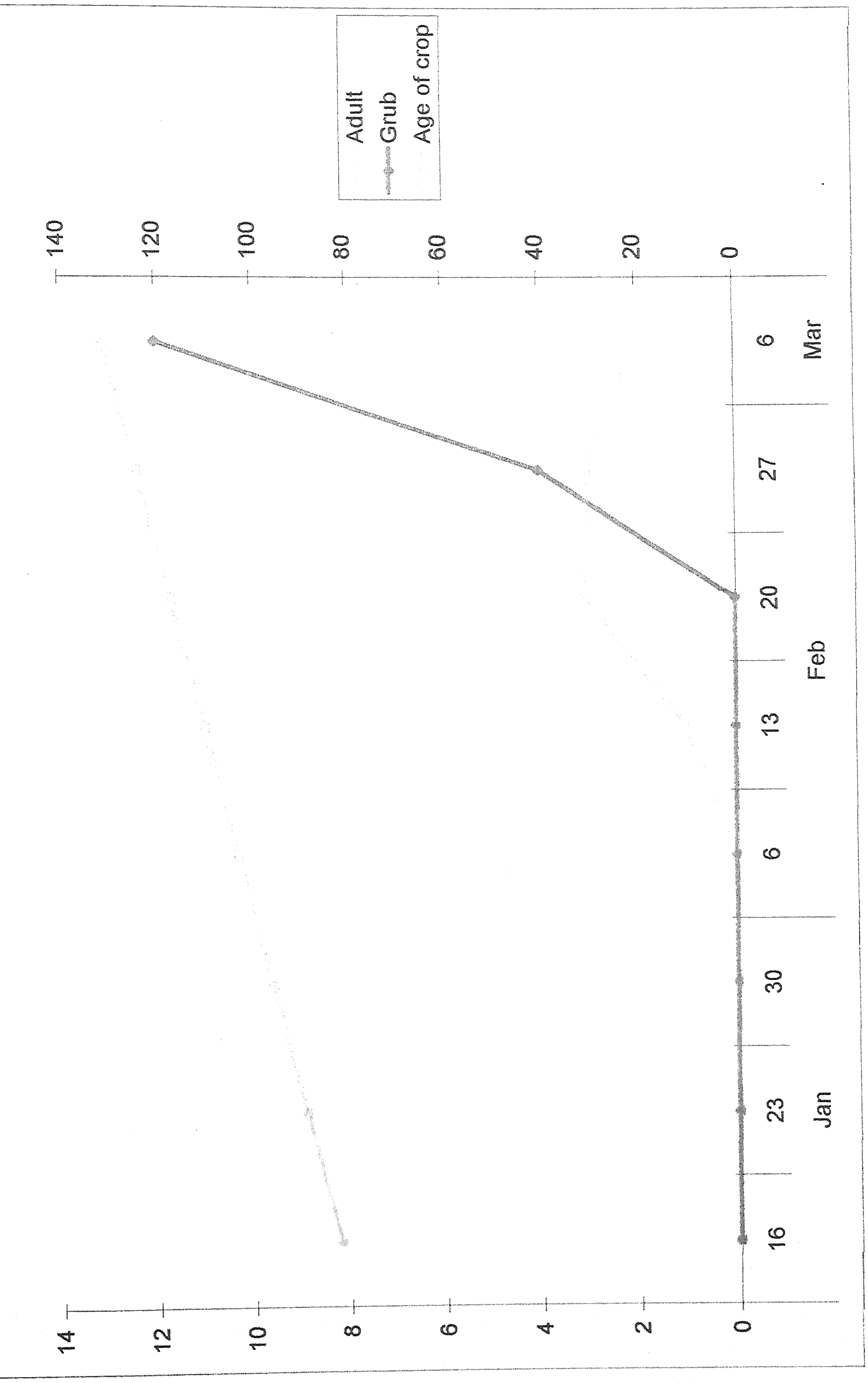


TABLE - 21

Population of Coccinellids on variety Vardan during 2005.

Date of observation		Age of the crop (days)	Adult	Grub
January	16	82	0	0
	23	89	0	0
	30	96	0	0
February	6	103	0	0
	13	110	2	0
	20	117	2	0
	27	124	3	3
March	6	131	2	10

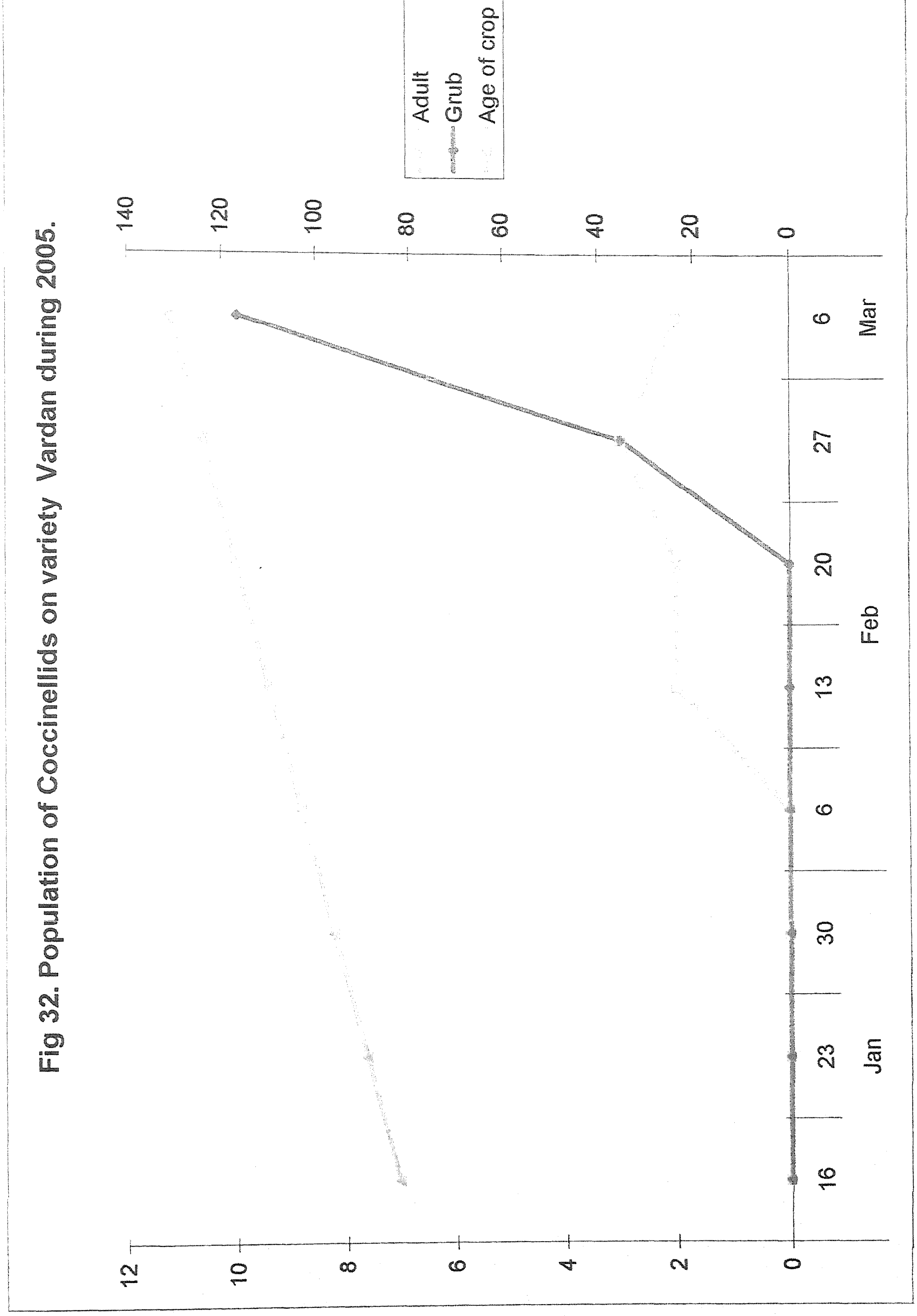


Fig 32. Population of Coccinellids on variety Vardan during 2005.

predators against aphid is that it never appeared during the perk activity period in January-February in any of the year under investigation

Regarding the effectiveness of Coccinellied predators, reported that the feeding efficiency of adults and gruds of *C. Septempunctata* was 80.70 and 89.90 aphids per day. The 4th instar larvae of the predator have been reported of consume more aphids by reported *C Septempunctata* Linn; *Menochilus sexmaculata* Fabr. and *Hipodania varyagata* as important predators of *L. erysimi.* The late appearance of the their suitability of multiplication on the temperature above 25 ^{0}C with less than 75 per cent relative humility. The adult and nymphs of these predators also found to feed on honey dew secreted by the aphids after their migration. The increase in predators' population at this time may play an important role in wiping out the aphid population.

3. APHID MULTIPLICATION:

The aphid intensity was found to increase at faster rate in the beginning being 0.40, 1.08, 12.05 and 39.05 on Varuna against 0.42, per plant per day on Rohini in the 3rd, 4th and 5th week of January and Ist week of February, respectively, during Ist Year (Table 22,23,24). There was increase in aphid population @ 0.19, 3.33 and 22.66 on Varuna; 0.19, 3.14, and 14.52 on Rohini and 0.20, 4.84 and 12.71 aphids per plant per day on Vardan (Table 25, 26, 27) during 3rd, 4th and 5th week of January and there was

TABLE - 22

Rate of multiplication of *L. erysimi* on variety Varuna during 2004.

Date of observation		Intensity rate of increasing per day	Infestation rate of increasing per day	Index rate of increase per day
January	17	0.40	7.61	0.08
	24	1.08	3.33	0.02
	31	13.05	0.95	0.14
February	7	39.05	1.90	0.20
	14	28.33	-0.95	-0.02
	21	-5.95	-1.90	0.00
	28	-51.66	-10.95	-0.42

Fig 33. Rate of multiplication of *L. erysimi* on variety Varuna during 2004.

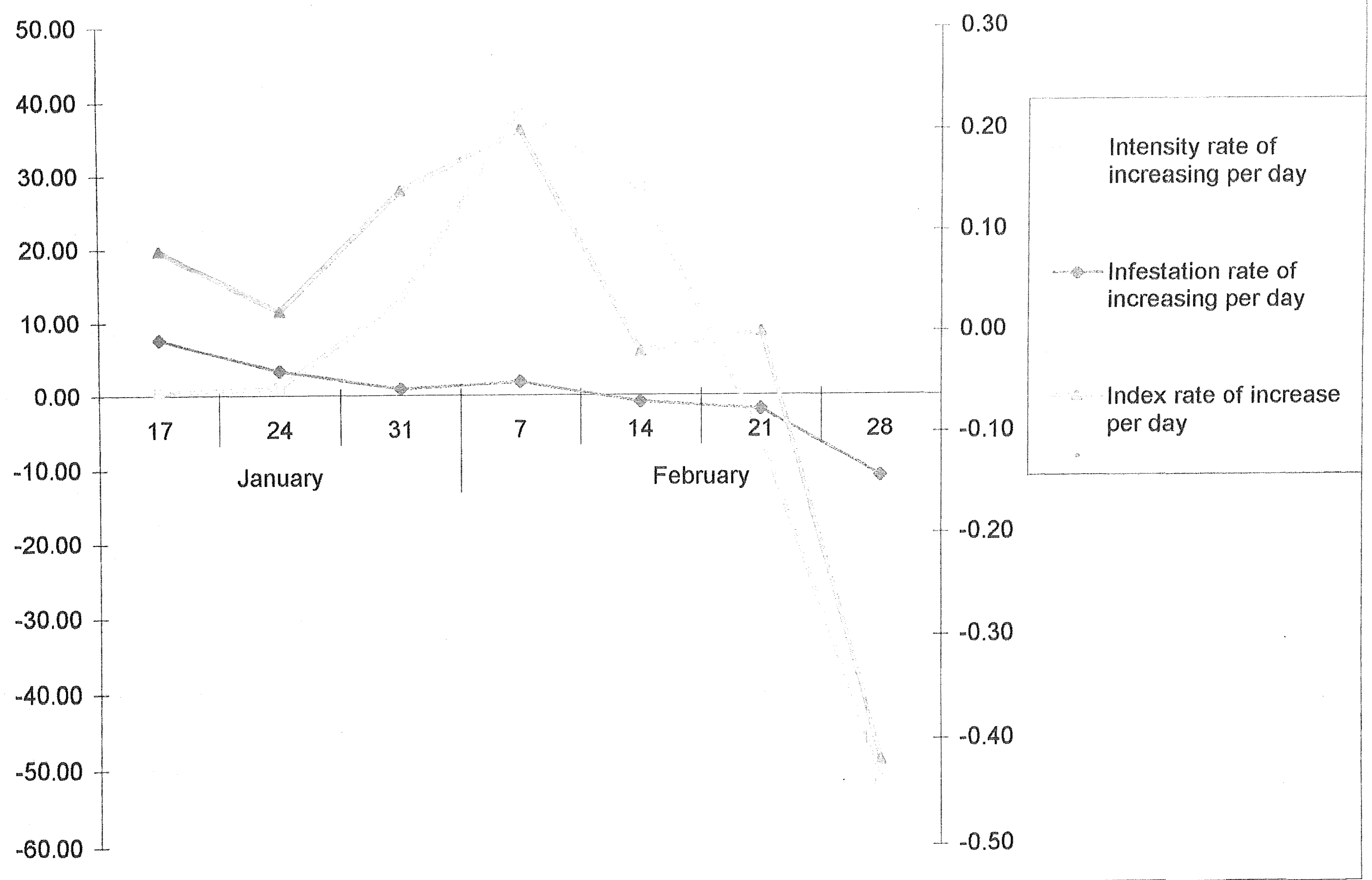


TABLE - 23

Rate of multiplication of *L. erysimi* on variety Rohini during 2004.

Date of observation		Intensity rate of increasing per day	Infestation rate of increasing per day	Index rate of increase per day
January	17	0.42	9.04	0.08
	24	3.38	3.33	0.05
	31	15.26	0.00	0.17
February	7	35.69	0.95	0.16
	14	1.19	0.47	-0.02
	21	-20.23	-1.42	0.00
	28	-35.71	-12.38	-0.45

Fig 34. Rate of multiplication of *L. erysimi* on variety Rohini during 2004.

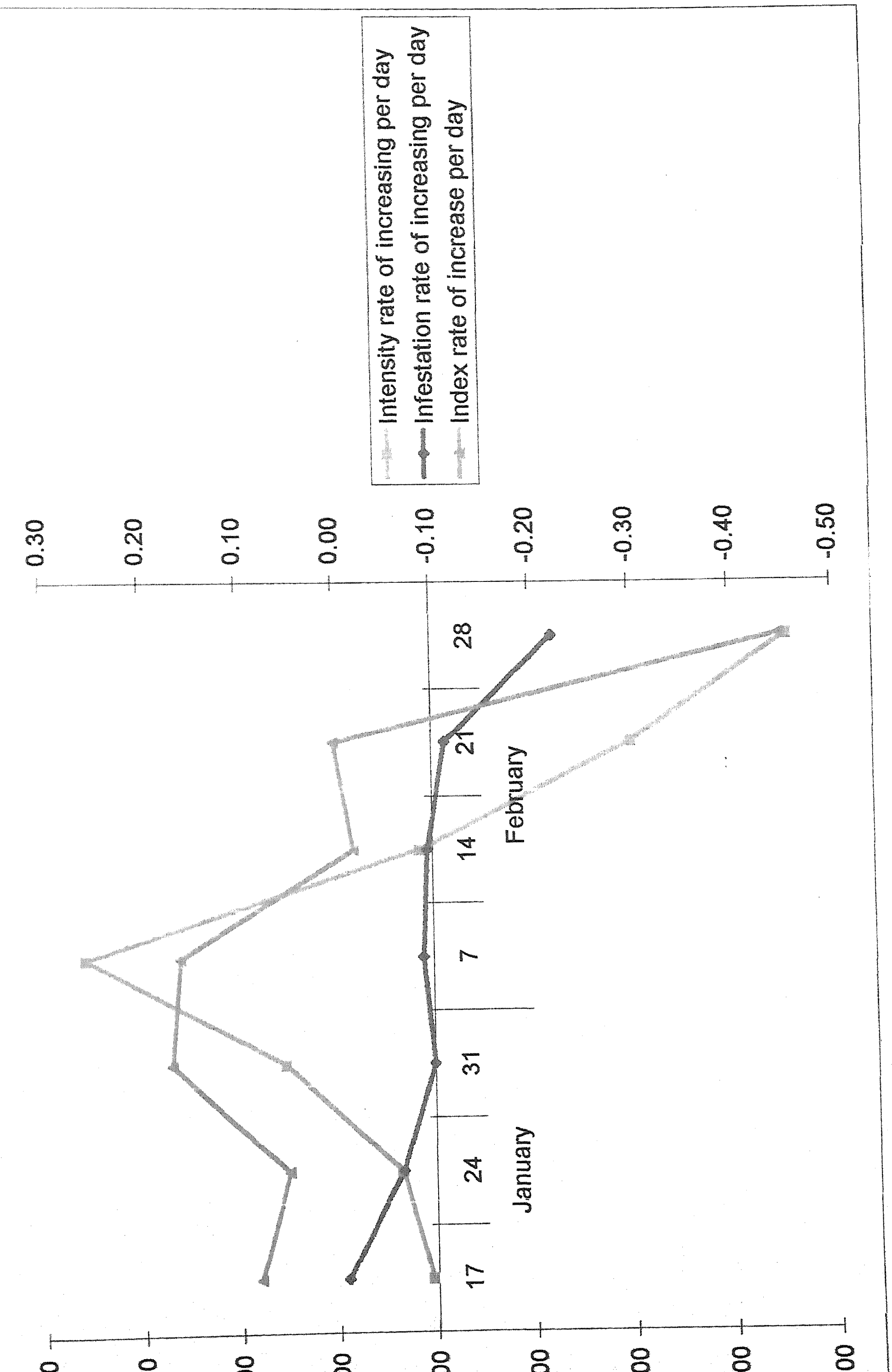


TABLE - 24

Rate of multiplication of *L. erysimi* on variety Vardan during 2004.

Date of observation		Intensity rate of increasing per day	Infestation rate of increasing per day	Index rate of increase per day
January	17	0.42	8.66	0.08
	24	4.09	3.23	0.03
	31	28.81	0.47	0.16
February	7	5.47	0.95	0.19
	14	12.38	-0.47	-0.04
	21	-7.47	-1.47	0.00
	28	-43.47	-11.42	-0.42

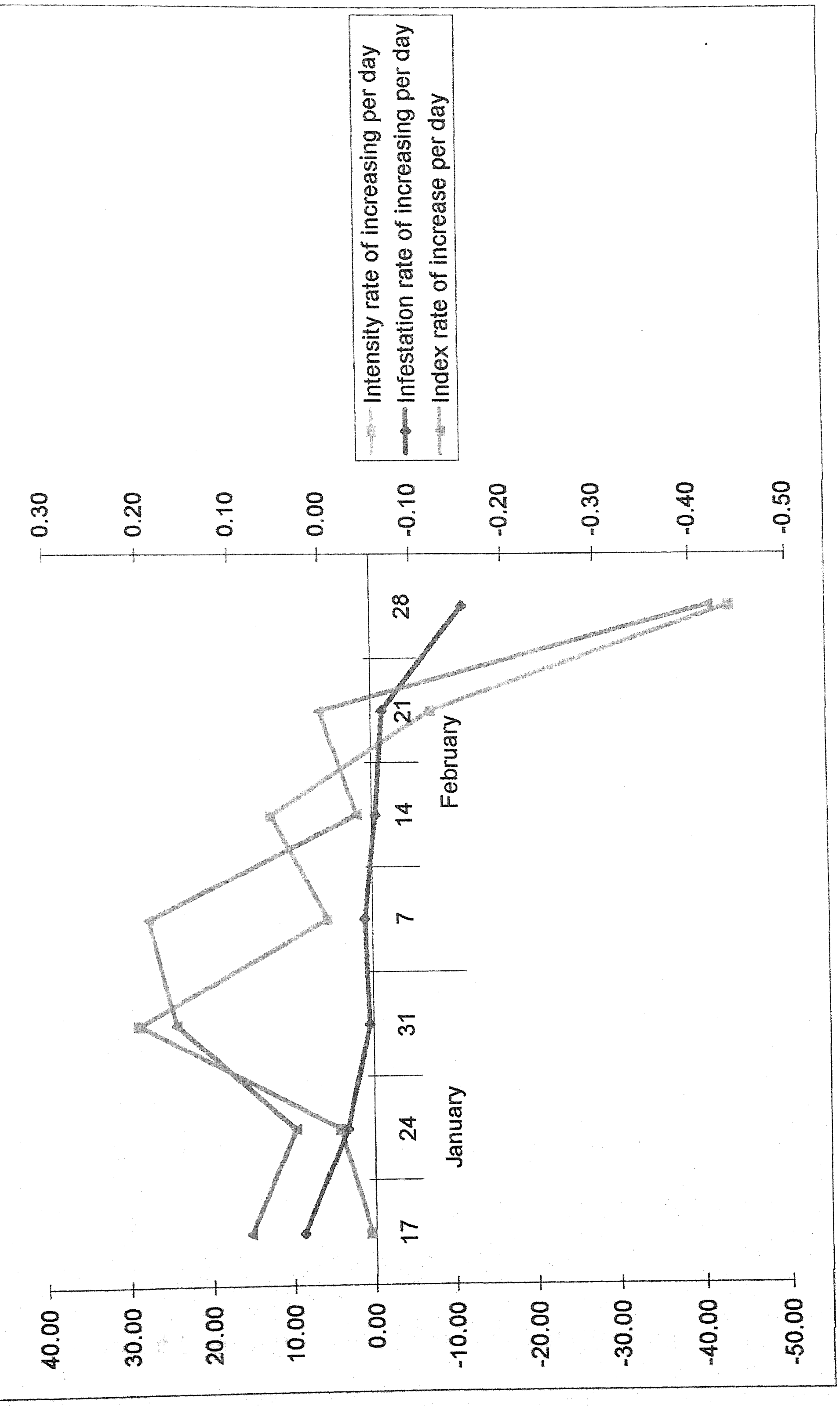


Fig 35. Rate of multiplication of *L. erysimi* on variety Vardan during 2004.

reduction in aphid multiplication rate per day in the second week of February and Ist week of February was at peak. Thereafter, sudden decrease in aphid multiplication rate was noticed with their complete wipe out from the field by the end of February and by 20th February in the second year [illegible]

The increase in aphid infestation percentage and indices were faster in the beginning and become slower with the increase in the flowering and adopted negative trend with the advancement in age of the crop on all three varieties during both the years.

Regarding aphid multiplication rate, Singh and Sandhu (1956) reported that multiplication of aphid is favoured by moist and cloudy weather which might be responsible for faster rate in aphid increase during 1st and 2nd week of February in the 1st year when the maximum humidity more than 80 (Maximum) and more than 50 per cent (minimum) lower humidity with minimum temperature 23.28 C were more conducive for increase in aphid population because of the cloudy weather having 19.4 mm total weekly rainfall at 87-94 days old crops on variety Varuna, but at 94 days during first year other two varieties did not behave at the same pattern. However, upto the age of 94 days during 2003-2004 and upto 103 days during 2004-2005, the aphid intensity and infestation were in positive direction and there was negative multiplication of aphid and it multiplication on different varieties of mustard of rapeseed and mustard. According to Goel and Singh (1994), natural increase of newly born nymphs of *L. erysimi* declined monotonically with the

TABLE - 25

Rate of multiplication of *L. erysimi* on variety Varuna during 2005.

Date of observation		Intensity rate of increasing per day	Infestation rate of increasing per day	Index rate of increase per day
January	16	0.19	5.71	0.06
	23	3.33	5.23	0.15
	30	22.66	1.42	0.07
February	6	11.57	-3.80	-0.02
	13	-4.57	-2.38	-0.04
	20	-33.09	-6.19	-0.20

Fig 36. Rate of multiplication of *L. erysimi* on variety Varuna during 2005.

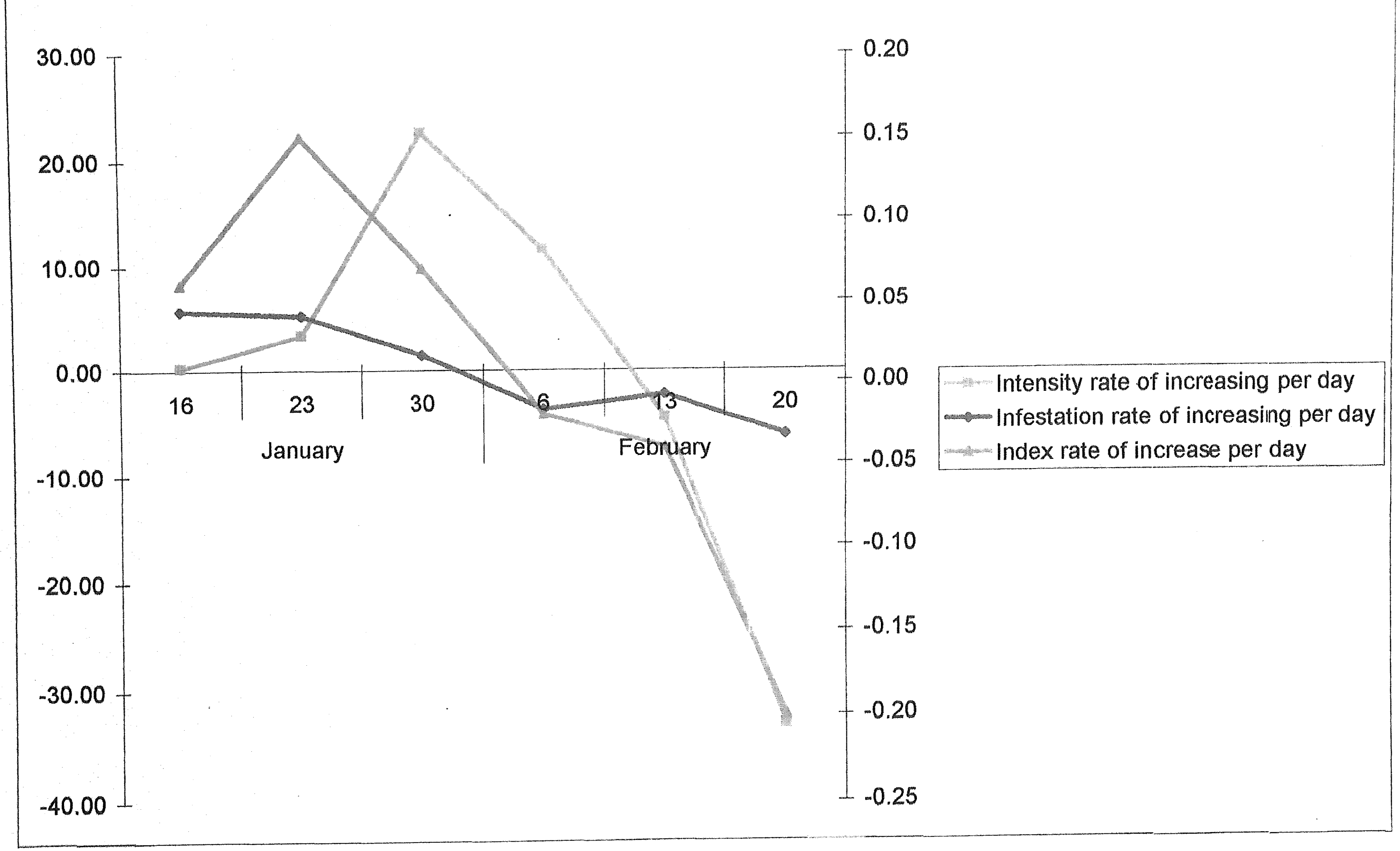


TABLE - 26

Rate of multiplication of *L. erysimi* on variety Rohini during 2005

Date of observation		Intensity rate of increasing per day	Infestation rate of increasing per day	Index rate of increase per day
January	16	0.19	7.61	0.06
	23	3.14	4.76	0.14
	30	14.52	1.42	0.11
February	6	9.09	-4.28	-0.07
	13	-1.69	-1.90	-0.04
	20	-25.26	-7.61	-0.02

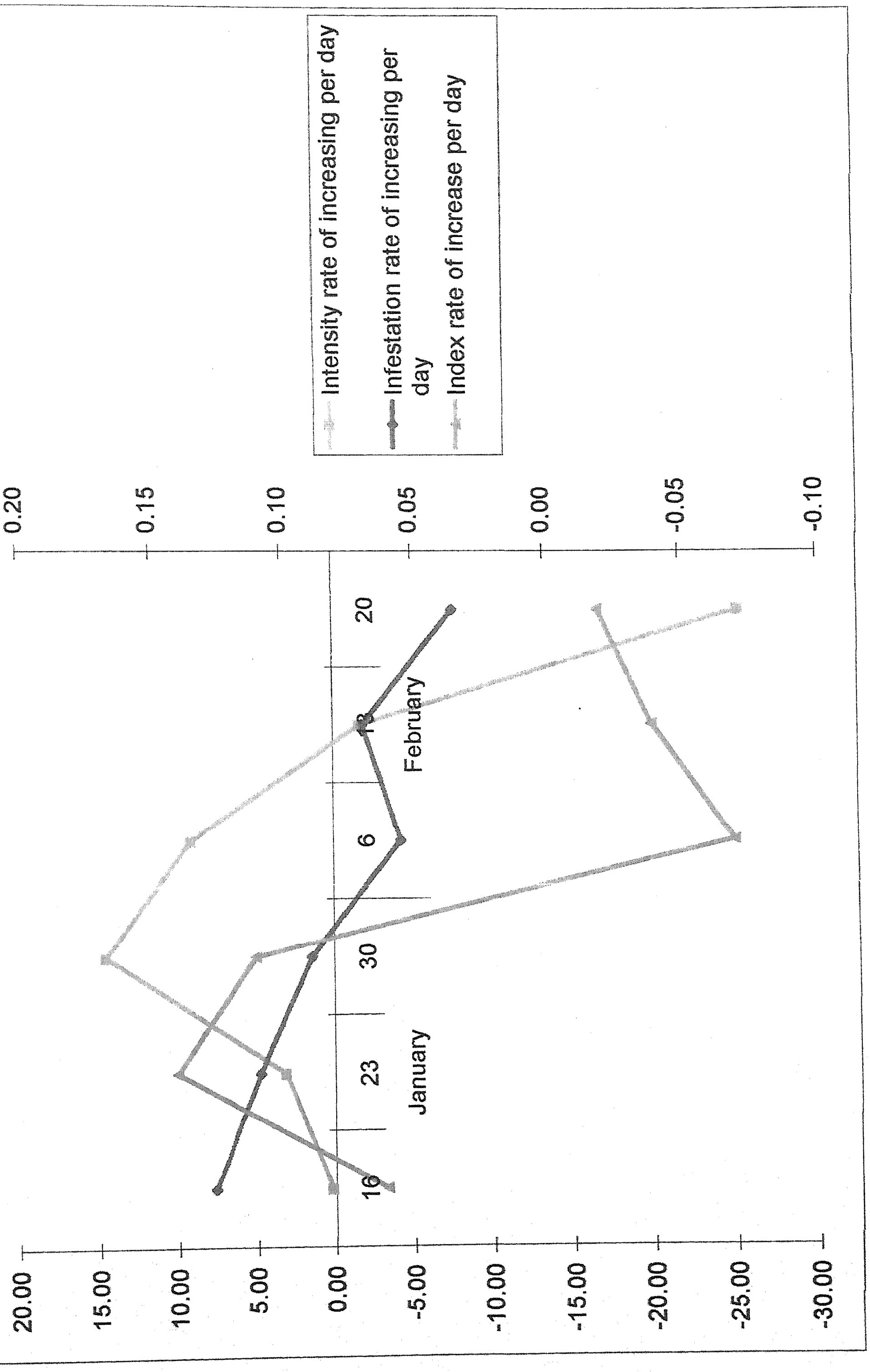


Fig 37. Rate of multiplication of *L. erysimi* on variety Rohini during 2005.

TABLE - 27

Rate of multiplication of *L. erysimi* on variety Vardan during 2005.

Date of observation		Intensity rate of increasing per day	Infestation rate of increasing per day	Index rate of increase per day
January	16	0.20	6.91	0.05
	23	4.84	5.71	0.15
	30	12.71	1.42	0.09
February	6	20.57	-5.28	-0.04
	13	-7.59	-1.42	-0.04
	20	-30.71	-6.61	-0.21

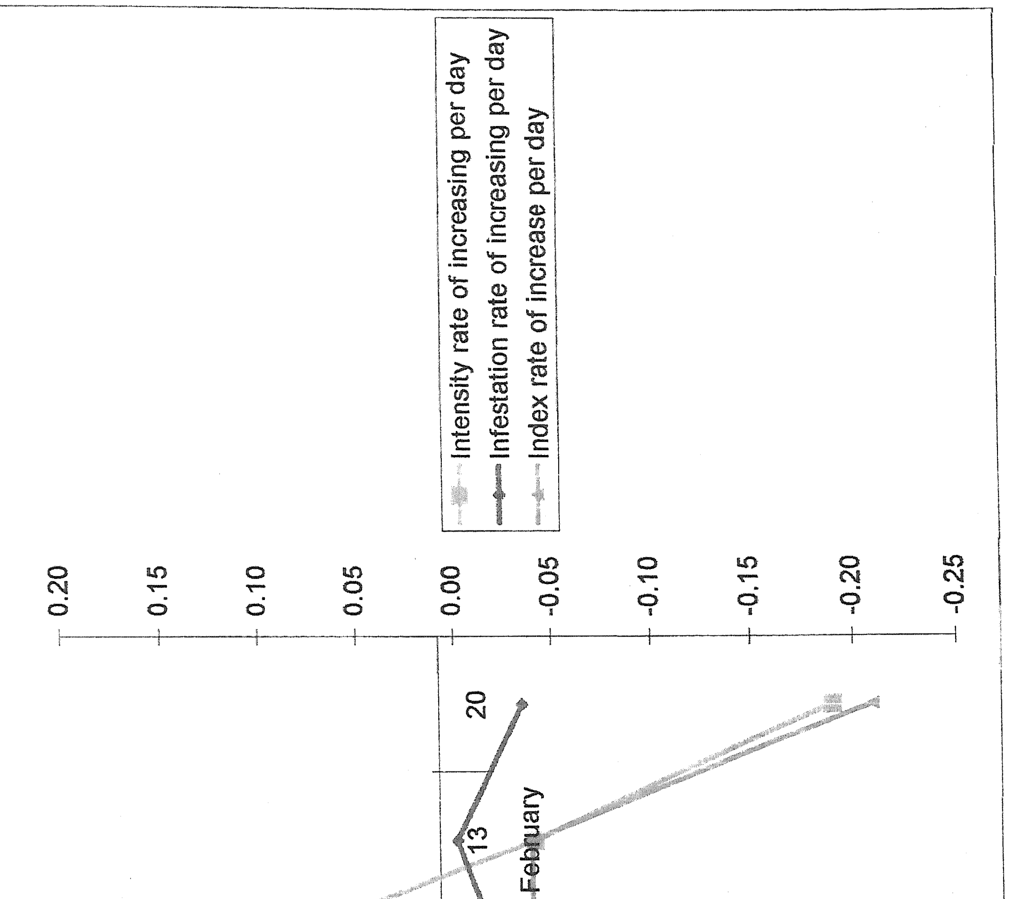


Fig 38. Rate of multiplication of *L. erysimi* on variety Vardan during 2005.

advancement in age of the crop during January, February and March, which may support the present findings regarding the reduction in aphid multiplication during February. Basavaraju et al. (1984) observed longer post reproductive period (7.75-8.37 days) and longevity (30-35 days) in *L. erysimi* along with greater number of 124-155 nymphs as compared to aphids derived from apterous parent having less reproductive period 0.37- 1.12 days with less longevity 17.75 to 18.12 days. This variation may be responsible for more number of aphids per day upto the end of January after that the progeny of apterous aphids may resulted in to accumulation of aphids on the plant. [illegible] and Sharma (1986) obtained significant variation in the reproduction period on different varieties of mustard that may cause variation in aphid multiplication on different varieties in the present investigation.

4. APHID FORECASTING MODEL:

In general, the development of the programme for best forcasting required prolonged infestation of any pest species and it is bit difficult to make any forecasting on the basis of pest appearance for the shorter period. The aphid population as evident from the findings on population dynamics indicates a very short persistence of aphids during both the years under investigation. However, efforts have been made to prepare aphid-forecasting model depending upon only few major environmental factors.

TABLE - 28

Various estimates and their coefficient of determination for aphid intensity on variety Varuna during 2004.

S.No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	◊ = $-444.0521 + 27.1289\ X_1$	9.81	9.81
2.	$y = f(X_1\ X_2)$	◊ = $-397.731 + 33.2961\ X_1 - 18.967\ X_2$	11.32	0.51
3.	$y = f(X_1\ X_2\ X_3)$	◊ = $-5395.6949 + 155.2959\ X_1 - 79.391\ X_2 + 35.7178\ X_3$	62.61	51.29
4.	$y = f(X_1\ X_2\ X_3\ X_4)$	◊ = $-5094.7442 + 129.6191\ X_1 - 50.4755\ X_2 + 39.839\ X_3 - 5.8907\ X_4$	62.83	0.22
5.	$y = f(X_1\ X_2\ X_3\ X_4\ X_5)$	◊ = $-5064.0914 + 97.2145\ X_1 - 1.1967\ X_2 + 39.839\ X_3 - 5.8907\ X_4 - 35.8634\ X_5$	65.04	2.21

X_1 = Maximum temprature, X_2 = Minimum temprature, X_3 = Relative humidity (Morning), X_4=Relative humidity (Evening), X_5 = Wind Speed.

TABLE - 29

Various estimates and their coefficient of determination for aphid intensity on variety Rohini during 2004.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\Diamond = -278.6216 + 19.5144\ X_1$	6.20	6.20
2.	$y = f(X_1\ X_2)$	$\Diamond = -216.4036 + 27.7981\ X_1 - 25.4762\ X_2$	9.53	3.33
3.	$y = f(X_1\ X_2\ X_3)$	$\Diamond = -5194.5471 + 149.3143\ X_1 - 85.6607\ X_2 + 35.5762\ X_3$	71.72	62.19
4.	$y = f(X_1\ X_2\ X_3\ X_4)$	$\Diamond = -4443.3195 + 85.2181\ X_1 - 13.4799\ X_2 + 45.8639\ X_3 - 14.7048\ X_4$	73.39	1.67
5.	$y = f(X_1\ X_2\ X_3\ X_4\ X_5)$	$\Diamond = -4393.1176 + 32.1471X_1 - 71.1467X_2 + 61.7528X_3 - 28.0736X_4 - 58.7357\ X_5$	80.62	7.23

X_1 = Maximum temprature, X_2 = Minimum temprature, X_3 = Relative humidity (Morning), X_4=Relative humidity (Evening), X_5 = Wind Speed.

TABLE - 30

Various estimates and their coefficient of determination for aphid intensity on variety Vardan during 2004.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\lozenge = -543.4778 + 31.2316\ X_1$	19.78	19.78
2.	$y = f(X_1 X_2)$	$\lozenge = -535.6785 + 32.5363\ X_1 - 4.0125\ X_2$	19.89	0.11
3.	$y = f(X_1 X_2 X_3)$	$\lozenge = -5078.4079 + 143.4242\ X_1 - 58.9330\ X_2 + 32.4645\ X_3$	84.34	64.45
4.	$y = f(X_1 X_2 X_3 X_4)$	$\lozenge = -4061.5474 + 56.6634\ X_1 - 38.7710\ X_2 + 46.3900\ X_3 - 19.9044\ X_4$	88.14	3.80
5.	$y = f(X_1 X_2 X_3 X_4 X_5)$	$\lozenge = -4063.6851 + 58.9233 X_1 - 35.1673 X_2 + 45.7145 X_3 - 19.335 X_4 - 2.5012\ X_5$	88.15	0.01

X_1 = Maximum temprature, X_2 = Minimum temprature, X_3 = Relative humidity (Morning), X_4=Relative humidity (Evening), X_5 = Wind Speed.

I. Forecasting Model During 2003-2004 :

The role of temperature was found to determine aphid intensity upto the extent of 19.78 per cent in case of variety Vardan during 2004 followed by 9.81 and 6.20 per cent on variety Vardan and Rohini. On the other hand, role of minimum temperature was very negligible while relative humidity (morning) responded upto the extent of 64.45, 62.19 and 51.29 per cent in determining the aphid population during evening hours, was not much prominent. Wind speed was found responsible for playing its role in determining aphid intensity upto the extent of 7.23 per cent in case of variety Rohini ([illegible])

The role of environmental factors was slightly different in determining the aphid infestation because the rate of increase of infestation was much faster than the rate of increase of aphid intensity and it was more than 90 per cent during main activity period of the aphid and completely eliminated with the change in the environmental conditions, that is why the role of both minimum and maximum temperature did not exceed 5 per cent and relative humidity was found to be responsible for determining the aphid infestation upto 90.54 per cent in case of Varuna, 85.98 per cent in case of Vardon and 84.33 per cent in case of Rohini. Wind speed was also not in conformity with those recorded in case of aphid intensity and it had shown only 3.5 per cent in case of variety Varuna (Table 31, 32, 33)

TABLE - 31

Various estimates and their coefficient of determination for aphid infestation on variety Varuna during 2004.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	◊ $=86.7268 -0.8111 X_1$	0.29	0.29
2.	$y = f(X_1 X_2)$	◊ $= 100.2307 +0.9868 X_1 -5.5294 X_2$	4.61	4.32
3.	$y = f(X_1 X_2 X_3)$	◊ $= -1044.7185 +28.9350 X_1 -19.3715 X_2 +8.1824 X_3$	95.15	90.54
4.	$y = f(X_1 X_2 X_3 X_4)$	◊ $= -1169.3336 +39.5674 X_1 -31.3450 X_2 + 6.4758 X_3 +2.4393 X_4$	96.41	1.26
5.	$y = f(X_1 X_2 X_3 X_4 X_5)$	◊ $= -1175.9981 +46.6127 X_1 -42.5795 X_2 + 4.3701 X_3 -4.2140 X_4 -7.7974 X_5$	99.92	3.51

X_1 = Maximum temprature, X_2 = Minimum temprature, X_3 = Relative humidity (Morning), X_4=Relative humidity (Evening), X_5 = Wind Speed.

TABLE - 32

Various estimates and their coefficient of determination for aphid infestation on variety Rohini during 2004.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\lozenge = -115.2412 - 0.8111\ X_1$	1.40	1.40
2.	$y = f(X_1\ X_2)$	$\lozenge = 100.2307 - 0.9868\ X_1 - 5.5294\ X_2$	4.30	2.90
3.	$y = f(X_1\ X_2\ X_3)$	$\lozenge = -1013.7922 + 27.5345\ X_1 - 18.4635\ X_2 + 8.1502\ X_3$	88.63	84.33
4.	$y = f(X_1\ X_2\ X_3\ X_4)$	$\lozenge = -1279.8212 + 33.0441\ X_1 - 12.7614\ X_2 + 10.7563\ X_3 - 1.6544\ X_4$	97.40	8.77
5.	$y = f(X_1\ X_2\ X_3\ X_4\ X_5)$	$\lozenge = -1178.5681 + 31.4970X_1 - 15.3105X_2 + 9.7428X_3 - 1.2986X_4 - 4.0883\ X_5$	98.07	0.67

X_1 = Maximum temprature, X_2 = Minimum temprature, X_3 = Relative humidity (Morning), X_4=Relative humidity (Evening), X_5 = Wind Speed.

TABLE - 33

Various estimates and their coefficient of determination for aphid infestation on variety Vardan during 2004.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	◊ = $107.8598 - 1.8242 X_1$	1.18	1.18
2.	$y = f(X_1 X_2)$	◊ = $119.3230 - 0.8969 X_1 - 4.6938 X_2$	4.32	3.14
3.	$y = f(X_1 X_2 X_3)$	◊ = $-992.3230 + 27.0441 X_1 - 18.1361 X_2 + 7.9460 X_3$	90.30	85.98
4.	$y = f(X_1 X_2 X_3 X_4)$	◊ = $-1251.4719 + 32.4063 X_1 - 12.5866 X_2 + 10.4824 X_3 - 1.6102 X_4$	99.20	8.90
5.	$y = f(X_1 X_2 X_3 X_4 X_5)$	◊ = $-1227.8420 + 32.0453 X_1 - 13.1814 X_2 + 10.2454 X_3 - 1.5271 X_4 - 0.9548 X_5$	99.24	0.04

X_1 = Maximum temprature, X_2 = Minimum temprature, X_3 = Relative humidity (Morning), X_4=Relative humidity (Evening), X_5 = Wind Speed.

TABLE - 34

Various estimates and their coefficient of determination for aphid indices on variety Varuna during 2004.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\hat{y} = -1.7300 + 0.1479\ X_1$	5.94	5.94
2.	$y = f(X_1\ X_2)$	$\hat{y} = -1.3533 + 0.1981\ X_1 - 0.1542\ X_2$	7.98	2.04
3.	$y = f(X_1\ X_2\ X_3)$	$\hat{y} = -39.8067 + 1.1367\ X_1 - 0.6191\ X_2 + 0.2748\ X_3$	69.83	61.85
4.	$y = f(X_1\ X_2\ X_3\ X_4)$	$\hat{y} = -43.2196 + 1.4279\ X_1 - 0.9471\ X_2 + 0.2281\ X_3 + 0.0668\ X_4$	70.41	0.58
5.	$y = f(X_1\ X_2\ X_3\ X_4\ X_5)$	$\hat{y} = -43.1007 + 1.3021\ X_1 - 0.7465\ X_2 + 0.2657\ X_3 - 0.0351\ X_4 - 0.1392\ X_5$	71.08	0.67

X_1 = Maximum temprature, X_2 = Minimum temprature, X_3 = Relative humidity (Morning), X_4=Relative humidity (Evening), X_5 = Wind Speed.

TABLE - 35

Various estimates and their coefficient of determination for aphid indices on variety Rohini during 2004

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	◊ = $-3.1012 + 0.2181 X_1$	12.14	12.14
2.	$y = f(X_1 X_2)$	◊ = $-2.8034 + 0.2577 X_1 - 0.1219 X_2$	13.34	1.20
3.	$y = f(X_1 X_2 X_3)$	◊ = $-46.4530 + 1.3232X_1 - 0.6496X_2 + 0.3119 X_3$	88.24	74.90
4.	$y = f(X_1 X_2 X_3 X_4)$	◊ = $-47.8611 + 1.4434 X_1 - 0.7849 X_2 + 0.2927 X_3 - 0.0276 X_4$	88.34	0.10
5.	$y = f(X_1 X_2 X_3 X_4 X_5)$	◊ = $-47.8324 + 1.4131X_1 - 0.7366X_2 + 0.3017X_3 - 0.0199X_4 - 0.0335 X_5$	88.37	0.03

X_1 = Maximum temprature, X_2 = Minimum temprature, X_3 = Relative humidity (Morning), X_4=Relative humidity (Evening), X_5 = Wind Speed.

TABLE - 36

Various estimates and their coefficient of determination for aphid indices on variety Vardan during 2004.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\hat{y} = -2.9388 + 0.2070 X_1$	11.54	11.54
2.	$y = f(X_1 X_2)$	$\hat{y} = -2.6597 - 0.2435 X_1 - 0.1123 X_2$	14.42	2.88
3.	$y = f(X_1 X_2 X_3)$	$\hat{y} = -45.0438 + 1.2781 X_1 - 0.6247 X_2 + 0.3029 X_3$	87.08	72.66
4.	$y = f(X_1 X_2 X_3 X_4)$	$\hat{y} = -47.4447 + 1.4829 X_1 - 0.8553 X_2 + 0.2700 X_3 - 0.0470 X_4$	87.36	0.28
5.	$y = f(X_1 X_2 X_3 X_4 X_5)$	$\hat{y} = -47.2768 + 1.3874 X_1 - 0.7080 X_2 + 0.2978 X_3 - 0.0228 X_4 - 0.0922 X_5$	87.65	0.29

X_1 = Maximum temprature, X_2 = Minimum temprature, X_3 = Relative humidity (Morning), X_4=Relative humidity (Evening), X_5 = Wind Speed.

The data depicted in Table 34, 35, 36 had shown different response of temperature in determining the aphid indices indicating 5.94, 12.14 negligible effect of minimum temperature. Besides, relative humidity (morning) was having 61.85, 74.90 and 72.66 per cent role of aphid indices of Var. Varuna, Rohini and Vardan, respectively. The wind speed could not found much responsible factor for determining aphid indices.

(ii) <u>Forecasting Model 2004-2005:</u>

The aphid intensity was found to be governed upto 18.13, 19.43, and 16.89 per cent by maximum temperature as against 35.28, 32.13 and 30.89 per cent role of minimum temperature on variety Varuna, Rohini and Vardan, respectively. The role of relative humidity prevailing during evening hours of the day was found to be responsible for determining the 28.23, 26.96 and 30.89 per cent of aphid intensity on the respective varieties. The wind speed determined 2.61 per cent of the aphid population on variety Vardon (Table 37, 38, and 39)

The aphid infestation had been found to be governed by temperature upto the extent of 7.72, 11.77 and 8.44 per cent. The relative humidity (Morning) could not show much confirming effect but evening relative humidity was found to control 43.58, 37.15 and 34.84 per cent of the aphid infestation. However, aphid infestation was found to be determined upto 30.36, 30.06 and 26.88 per cent by wind speed on the respective varieties (Table 40, 41 &42)

TABLE - 37

Various estimates and their coefficient of determination for aphid intensity on variety Varuna during 2005.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\hat{y} = -143.5586 - 11.4174\ X_1$	18.13	18.13
2.	$y = f(X_1\ X_2)$	$\hat{y} = -1437.0996 - 20.4850\ X_1 - 11.3378 X_2$	53.41	35.28
3.	$y = f(X_1\ X_2\ X_3)$	$\hat{y} = -1688.0137 - 18.7513\ X_1 - 7.5368\ X_2 + 8.1457\ X_3$	81.64	28.23
4.	$y = f(X_1\ X_2\ X_3\ X_4)$	$\hat{y} = -1729.5565 + 20.2783\ X_1 - 8.2750\ X_2 + 7.9471\ X_3 - 8.0718\ X_4$	81.69	0.05

X_1 = Maximum temprature, X_2 = Relative humidity (Morning), X_3=Relative humidity (Evening), X_4 = Wind Speed.

TABLE - 38

Various estimates and their coefficient of determination for aphid intensity on variety V_2 Rohini during 2005.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\Diamond = -108.8198 + 8.5348 X_1$	19.43	19.43
2.	$y = f(X_1 X_2)$	$\Diamond = -977.2363 - 13.4057 X_1 - 7.7901 X_2$	51.56	32.13
3.	$y = f(X_1 X_2 X_3)$	$\Diamond = -1153.8123 - 12.1856 X_1 - 5.1152 X_2 - 5.7324 X_3$	78.52	29.96
4.	$y = f(X_1 X_2 X_3 X_4)$	$\Diamond = -1122.1179 - 11.0206 X_1 - 4.6283 X_2 - 5.8835 X_3 - 6.1583 X_4$	78.58	0.06

X_1 = Maximum temprature, X_2 = Relative humidity (Morning), X_3=Relative humidity (Evening), X_4 = Wind Speed.

TABLE - 39

Various estimates and their coefficient of determination for aphid intensity on variety Vardan during 2005.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\Diamond = -128.8298 + 10.3575\ X_1$	16.89	16.89
2.	$y = f(X_1\ X_2)$	$\Diamond = 1257.6863 - 17.6528\ X_1 - 9.9452\ X_2$	47.78	30.89
3.	$y = f(X_1\ X_2\ X_3)$	$\Diamond = 1519.0584 + 15.8468\ X_1 - 5.9858\ X_2 - 8.4852\ X_3$	82.64	34.86
4.	$y = f(X_1\ X_2\ X_3\ X_4)$	$\Diamond = 1239.9951 - 5.5814\ X_1 - 1.7072\ X_2 - 9.8081\ X_3 - 54.2140\ X_4$	82.25	2.61

X_1 = Maximum temprature, X_2 = Relative humidity (Morning), X_3=Relative humidity (Evening), X_4 = Wind Speed.

TABLE - 40

Various estimates and their coefficient of determination for aphid infestation on variety Varuna during 2005.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\Diamond = 94.2264 - 1.8903\ X_1$	7.72	7.72
2.	$y = f(X_1\ X_2)$	$\Diamond = 36.8328 - 0.7309\ X_1 + 0.4117\ X_2$	8.44	0.72
3.	$y = f(X_1\ X_2\ X_3)$	$\Diamond = 115.7198 - 0.1858\ X_1 + 1.6067\ X_2 - 2.5610\ X_3$	52.02	43.58
4.	$y = f(X_1\ X_2\ X_3\ X_4)$	$\Diamond = -6.4346 + 0.0111\ X_1 + 0.1912\ X_2 + 0.0612\ X_3 + 0.0040\ X_4$	82.38	30.36

X_1 = Maximum temprature, X_2 = Relative humidity (Morning), X_3=Relative humidity (Evening), X_4 = Wind Speed.

TABLE - 41

Various estimates and their coefficient of determination for aphid infestation on variety Rohini during 2005.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\Diamond = 117.9508 - 2.5651\ X_1$	11.47	11.47
2.	$y = f(X_1 X_2)$	$\Diamond = 67.3672 - 1.5433\ X_1 + 0.3628\ X_2$	12.24	0.47
3.	$y = f(X_1 X_2 X_3)$	$\Diamond = 147.4094 - 0.9902\ X_1 + 1.5754\ X_2 - 2.5985\ X_3$	49.39	37.15
4.	$y = f(X_1 X_2 X_3 X_4)$	$\Diamond = -6.4650 + 0.0089\ X_1 - 0.1980\ X_2 + 0.0650\ X_3 - 0.0013\ X_4$	79.45	30.15

X_1 = Maximum temprature, X_2 = Relative humidity (Morning), X_3=Relative humidity (Evening), X_4 = Wind Speed.

TABLE - 42

Various estimates and their coefficient of determination for aphid infestation on variety Vardan during 2005.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\Diamond = 102.0896 - 2.1181\ X_1$	8.44	8.44
2.	$y = f(X_1\ X_2)$	$\Diamond = -2.3939 - 0.0074\ X_1 - 0.7494\ X_2$	10.54	2.10
3.	$y = f(X_1\ X_2\ X_3)$	$\Diamond = 73.1764 + 0.5148\ X_1 - 1.8942\ X_2 - 2.4533\ X_3$	45.38	34.84
4.	$y = f(X_1\ X_2\ X_3\ X_4)$	$\Diamond = 331.1910 -- 8.9690\ X_1 - 2.0697\ X_2 + 1.2233\ X_3 - 50.1326\ X_4$	72.26	26.88

X_1 = Maximum temprature, X_2 = Relative humidity (Morning), X_3=Relative humidity (Evening), X_4 = Wind Speed.

TABLE - 43

Various estimates and their coefficient of determination for aphid indices on variety Varuna during 2005.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\Diamond = 0.7018 + 0.0223\ X_1$	1.58	1.58
2.	$y = f(X_1\ X_2)$	$\Diamond = 3.0775 - 0.0257\ X_1 - 0.0170\ X_2$	3.41	1.83
3.	$y = f(X_1\ X_2\ X_3)$	$\Diamond = 5.4111 - 0.0096\ X_1 + 0.0183\ X_2 - 0.0758\ X_3$	59.66	56.26
4.	$y = f(X_1\ X_2\ X_3\ X_4)$	$\Diamond = 8.6918 - 0.1294\ X_1 - 0.0329\ X_2 - 0.0594\ X_3 + 0.6382\ X_4$	67.56	7.90

X_1 = Maximum temprature, X_2 = Relative humidity (Morning), X_3=Relative humidity (Evening), X_4 = Wind Speed.

TABLE - 44

Various estimates and their coefficient of determination for aphid indices on variety Rohini during 2005.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\lozenge = 0.7883 + 0.0211\ X_1$	1.21	1.21
2.	$y = f(X_1 X_2)$	$\lozenge = 3.8059 - 0.0397\ X_1 - 0.02317 X_2$	3.74	2.53
3.	$y = f(X_1 X_2 X_3)$	$\lozenge = 6.0880 - 0.0219\ X_1 + 0.0144\ X_2 - 0.0764\ X_3$	52.44	48.70
4.	$y = f(X_1 X_2 X_3 X_4)$	$\lozenge = 11.6388 - 0.2264\ X_1 - 0.0717\ X_2 - 0.0494\ X_3 + 1.0901\ X_4$	71.08	16.64

X_1 = Maximum temprature, X_2 = Relative humidity (Morning), X_3=Relative humidity (Evening), X_4 = Wind Speed.

TABLE - 45

Various estimates and their coefficient of determination for aphid indices on variety Vardan during 2005.

S. No.	Model	Estimating model	Coefficient determination (R^2)	Difference in variability explained independent variable
1.	$y = f(X_1)$	$\lozenge = 0.6590 + 0.0251\ X_1$	1.83	1.18
2.	$y = f(X_1\ X_2)$	$\lozenge = 3.2394 - 0.0269\ X_1 - 0.0185\ X_2$	3.80	1.97
3.	$y = f(X_1\ X_2\ X_3)$	$\lozenge = 5.5431 - 0.0089\ X_1 + 0.0179\ X_2 - 0.0771\ X_3$	56.76	52.96
4.	$y = f(X_1\ X_2\ X_3\ X_4)$	$\lozenge = 10.1824 - 0.1799\ X_1 - 0.0541\ X_2 - 0.0545\ X_3 + 1.9111\ X_4$	70.65	13.89

X_1 = Maximum temprature, X_2 = Relative humidity (Morning), X_3=Relative humidity (Evening), X_4 = Wind Speed.

The effect of relative humidity during evening hours of the day was responsible for determining 56.25, 48.70 and 52.96 per cent of aphid indices (Table 43, 44, &45) while wind speed governed 7.90, 16.64 and 13.89 per cent of the aphid indices on variety Varuna, Rohini and Vardan, respectively.

On the basis of the forecasting model developed for two consecutive years it is evident that maximum temperature determined the aphid intensity upto 9.81, 6.20 and 19.78 per cent, if aphid appeared earlier during flowering stage, the role of temperature was found to be negative and governed 18.13, 19.43 and 16.89 per cent of the aphid intensity, as observed during second year of the experiment. The relative humidity was found to be controlled 51.29, 62.19 and 64.45 per cent of the aphid intensity but it had shown negative response during the second year being 35.28, 32.13 and 30.89 per cent impact in determining aphid intensity, because of the appearance of the aphid during late flowering stage of the crop. Wind speed was found to be slightly conducive during the Ist year against the contrary effect during second year. The aphid infestation and aphid infestation indices were showing identical effect only on some occasions but varying usually because of rapid change in aphid infestation and its indices in comparison to aphid intensity.

Atwal *et al.* (1971) had shown that fluctuations in aphid population are mainly governed by high temperature and maturity of food, but Srivastava and Srivastava (1972) and Roy (1975) had shown that

aphid population was dependent on the effect of temperature and humidity. Chandra and Kushwaha (1986) indicated that in initial rising phase and ultimate falling phase aphid population in negatively correlated with temperature and positively correlated with relative humidity. Mathur and Singh (1986 b) had shown that maximum temperature above 30 C and minimum above 15 C with relative humidity below 75 per cent and increase in wind speed more than 3 m/hr and evaporation rate 5mm per day had their combined effect on a sudden fall of the aphid population. Rana (1987) determined more than 80 per cent role of the cultural practices on aphid. Rana *et al.* (1993) obtained a good contribution of the abitotic factors like temperature, humidity and rainfall collectively accounted for 67.51 and 52.45 per cent of the aphid population. Bhattacharya *et al.* (1995) advocated that aphid population growth was highest in the later part of the vegetative stage of crop and gradually was highest in the later part of the vegetative stage of crop and gradually declined during the flowering and fruiting stage. Thus, the abiotic factors like temperature, relative humidity, wind speed etc. are major factors in determining the aphid population, though they had verifying impact on aphid population with the advancement in the age of the crop.

5 VARIETAL RESPONSE:

The varieties Varuna, Rohini and Vardan of mustard *B. Juncea* are having distinct inheritable characters (Table 46, 47, & 48) Variety Rohini was having maximum plant height and minimum number of branching per plant,

TABLE - 46

General phenotypical characters of different varieties of mustard.

S. No.	Characters	Phenotypical character of Varuna	Phenotypical character of Rohini	Phenotypical character of Vardan
1.	Seed size	Bold	Bold	Medium
2.	Stem	Greenish	Greenish	Yellowish
3.	Leaf	Hairyness in lower surface	Smooth	Smooth
4.	Flowering initiation (Days)	40 - 45	45 - 50	38 - 42
5.	Flowering duration (Days)	Upto 80 - 85	80 - 90	82 - 90
6.	Type of flower	Cluser	Elongated raceme	Cluser
7.	Flower colour	Yellow	Yellow	Yellow
8.	Siliquae	Non - apress	Apress	Non - apress

TABLE - 47

General numerical characters of different varieties of mustard.

S. No.	Characters	Varuna			Rohini			Vardan		
		2004	2005	Average	2004	2005	Average	2004	2005	Average
1.	Plant height(m)	1.66	1.65	1.66	1.83	1.83	1.83	1.41	1.40	1.41
2.	Branching	3.00	3.33	3.16	3.33	3.33	3.33	4.66	4.60	4.63
3.	Test Weight	5.50	5.50	5.50	4.60	4.80	4.70	2.83	3.00	2.92
4.	Oil Content (%)	36.50	37.90	37.20	40.46	40.50	40.48	40.09	39.90	40.00
5.	Germination (%)	90.66	91.00	90.83	91.00	93.00	92.00	92.33	93.66	93.00

TABLE - 48

Mean aphid incidence on different varieties of mustard

S. No.	Characters	Varuna			Rohini			Vardan		
		2004	2005	Average	2004	2005	Average	2004	2005	Average
1.	Intensity	217.00	142.60	180.00	201.16	110.86	156.01	224.47	139.10	181.74
2.	Infestation	78.57	57.22	67.90	85.71	68.33	77.02	83.04	61.11	72.08
3.	Index	2.05	1.46	1.76	2.36	1.52	1.94	2.25	1.48	1.87

and Varuna was having more tall plants in comparison to Vardan which had maximum number of branching along with the nature of early flowering at the age of 38 to 42 days which prolong upto 90 days stage. On the other hand, flowering duration was more of less identical in Varuna and Rohini. The test weight of Varuna (5.50g) was significantly higher than that of Rohini (4.70g) and Varuna (2.92g). The oil content was obtained to be maximum 40.46 per cent in Rohini, 40.96 in Vardan against 37.20 per cent in Varuna without any insecticidal treatment (Table 40 to 44). The normal germination of Varuna, Rohini and Vardan was found to be 93.83, 92.090 and 93.00 percent, respectively, having significant differences among themselves (Fig. 41 to 50)

The aphid intensity was slightly higher 181.75 on Vardan followed by Varuna 180.00 and Rohini 156.01 on central main shoot per plant, while infestation and infestation and infestation indices were maximum 77.02 per cent and 1.94 on Variety Rohini followed by 72.08 per cent and 1.87 on Vardan and 67.90 per cent and 1.76 on Variety Varuna, respectively (Table 40, 41, ... 46 and Fig. 38 to 44)

IMPROVEMENT IN PLANT CHARACTERISTICS BY INSECTICIDAL APPLICATION:

(I) Plant Height:

The average plant height of 1.66 and 1.65 m of the untreated control plots was found to be gradually increased by the repeated application of

TABLE - 49

Effect of insecticidal treatments on aphid population on Varuna during 2004.

Treatment	Characters					Aphid incidence		
	Plant height (m)	Branching/ plant	Test Weight (g)	Oil content (%)	Germination	Intensity	infestation	index
T_1	1.80	5.33	6.60	38.87	98.23	2.11	14.28	0.19
T_2	1.78	5.00	6.06	38.57	97.66	4.17	33.80	0.36
T_3	1.76	4.66	6.03	37.87	96.33	11.56	49.05	0.47
T_4	1.73	4.00	6.03	37.87	96.00	57.65	54.76	0.70
T_5	1.70	3.66	6.00	37.23	92.66	106.97	62.85	1.08
T_6	1.65	3.33	5.76	36.89	92.33	161.62	70.47	1.61
T_7	1.66	3.00	5.76	36.50	90.66	217.40	78.57	2.05
Mean	**1.73**	**4.14**	**5.50**	**37.63**	**94.85**	**80.21**	**51.97**	**0.92**

TABLE - 50

Effect of insecticidal treatments on aphid population on Rohini during 2004.

Treatment	Characters					Aphid incidence		
	Plant height (m)	Branching/ plant	Test Weight (g)	Oil content (%)	Germination	Intensity	infestation	index
T_1	1.77	5.00	5.56	42.50	99.66	2.13	21.42	0.19
T_2	1.94	4.66	5.53	42.27	99.00	4.49	34.28	0.36
T_3	1.92	4.33	5.50	42.07	96.66	18.40	45.23	0.58
T_4	1.90	4.00	5.10	41.38	98.00	64.13	54.28	0.85
T_5	1.89	3.66	4.90	40.97	96.33	102.37	64.28	1.33
T_6	1.88	3.33	4.73	40.95	93.66	136.91	73.80	1.80
T_7	1.83	3.33	4.60	40.46	91.00	201.16	85.70	2.36
Mean	**1.90**	**4.04**	**5.14**	**41.51**	**96.62**	**75.80**	**54.15**	**1.07**

TABLE - 51

Effect of insecticidal treatments on aphid population on Vardan during 2004.

Treatment	Characters					Aphid incidence		
	Plant height (m)	Branching/ plant	Test Weight (g)	Oil content (%)	Germination	Intensity	infestation	index
T_1	1.49	6.66	4.60	41.41	99.33	2.22	23.33	0.19
T_2	1.47	6.33	4.40	41.16	96.66	2.52	33.33	0.35
T_3	1.46	6.00	3.56	41.09	96.33	32.76	46.66	0.65
T_4	1.45	5.66	3.13	40.83	96.00	65.32	53.33	0.87
T_5	1.44	5.33	3.06	40.64	94.66	99.00	63.33	1.38
T_6	1.43	5.00	3.00	40.51	93.00	140.66	70.66	1.83
T_7	1.41	4.66	2.83	40.09	92.33	224.47	83.04	2.25
Mean	**1.45**	**5.67**	**3.45**	**40.82**	**95.48**	**80.21**	**53.38**	**1.07**

TABLE - 52

Effect of insecticidal treatments on aphid population on Varuna during 2005

Treatment	Characters					Aphid incidence		
	Plant height (m)	Branching/ plant	Test Weight (g)	Oil content (%)	Germination	Intensity	infestation	index
T_1	1.81	5.00	6.50	40.10	99.23	1.25	13.33	0.16
T_2	1.76	4.66	6.30	39.90	97.33	3.94	23.33	0.25
T_3	1.75	4.33	6.10	39.50	97.00	22.98	37.22	0.64
T_4	1.73	4.00	6.00	39.00	96.33	48.30	42.78	0.90
T_5	1.66	3.66	5.80	38.35	95.33	106.94	51.11	1.23
T_6	1.65	3.33	5.50	37.90	91.00	142.64	57.22	1.46
Mean	**1.73**	**4.16**	**6.05**	**39.12**	**96.05**	**54.34**	**37.50**	**0.78**

TABLE - 53

Effect of insecticidal treatments on aphid population on Rohini during 2005

Treatment	Characters					Aphid incidence		
	Plant height (m)	Branching/ plant	Test Weight (g)	Oil content (%)	Germination	Intensity	infestation	index
T_1	1.96	4.66	5.83	42.20	100.00	1.24	15.00	1.87
T_2	1.93	4.33	5.50	41.85	98.33	3.82	22.77	0.32
T_3	1.91	4.00	5.50	41.50	98.00	21.30	36.11	0.72
T_4	1.89	3.66	5.00	41.29	97.66	52.75	44.44	0.99
T_5	1.88	3.33	85.00	41.00	96.33	80.61	51.11	1.35
T_6	1.83	3.33	4.80	40.50	93.00	110.86	68.33	1.52
Mean	**1.90**	**3.83**	**5.22**	**41.39**	**97.22**	**45.10**	**39.63**	**0.85**

TABLE - 54

Effect of insecticidal treatments on aphid population on Vardan during 2005

Treatment	Characters					Aphid incidence		
	Plant height (m)	Branching/ plant	Test Weight (g)	Oil content (%)	Germination	Intensity	infestation	index
T_1	1.48	6.30	4.50	41.50	100.00	1.12	12.22	0.16
T_2	1.46	6.00	3.50	41.40	98.33	5.30	23.89	0.31
T_3	1.45	5.60	3.06	41.22	96.66	22.33	35.55	0.66
T_4	1.43	5.33	3.00	41.00	96.00	52.31	43.33	0.87
T_5	1.41	5.00	3.00	40.57	95.33	99.06	54.44	1.23
T_6	1.40	4.60	3.00	39.90	93.66	139.10	61.11	1.48
Mean	**1.73**	**4.16**	**6.05**	**39.12**	**96.05**	**53.20**	**38.42**	**0.79**

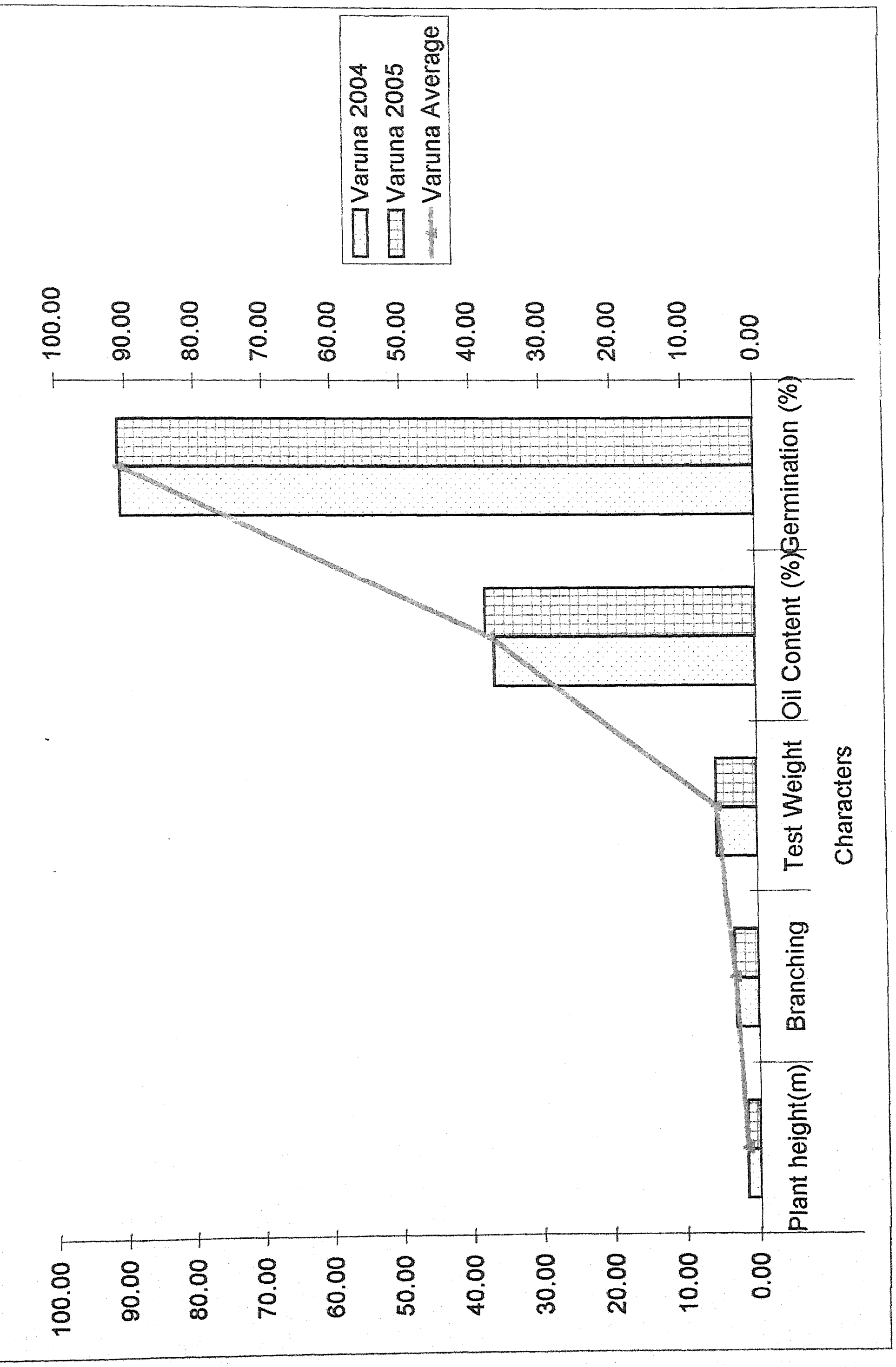
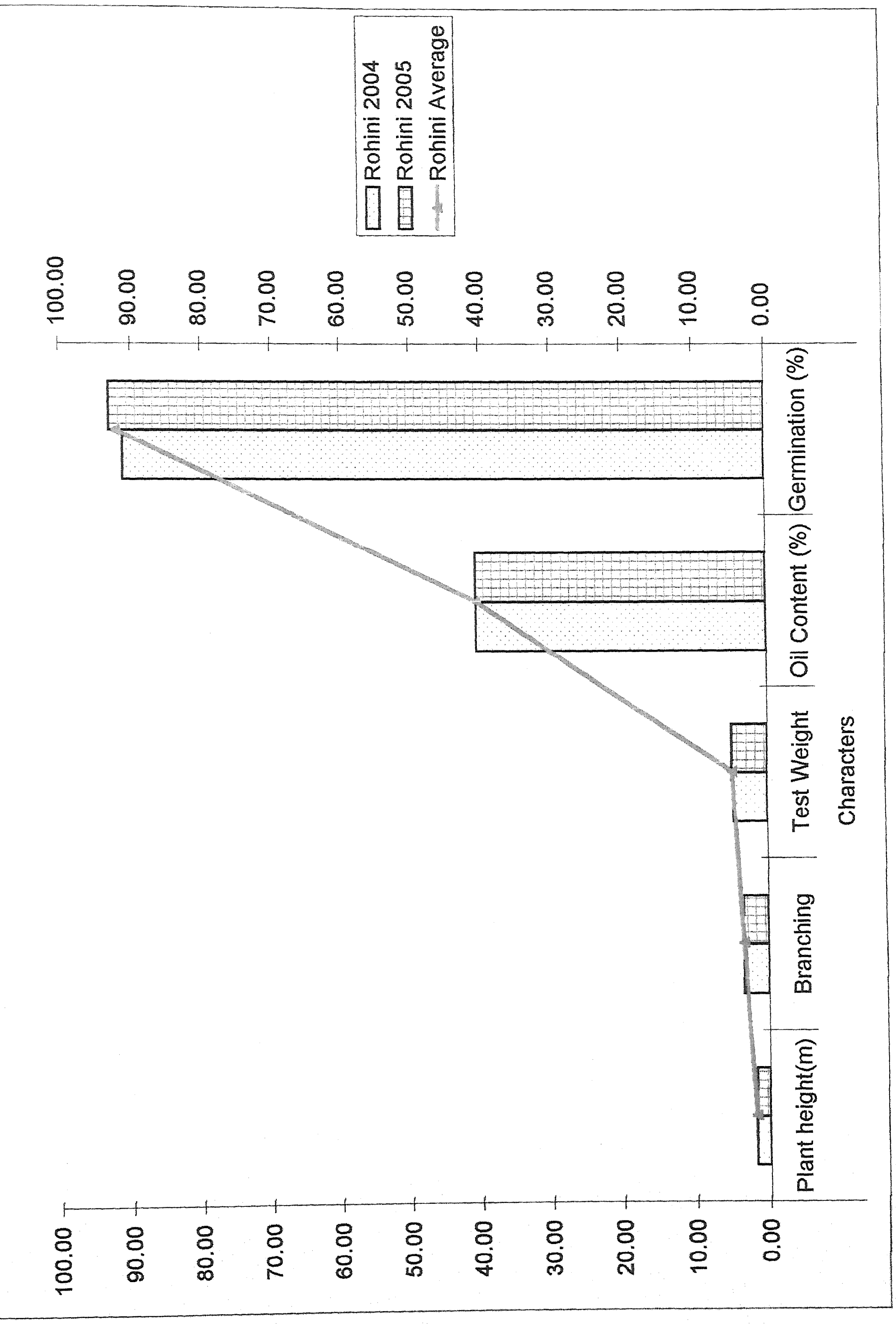


Fig 39. General numerical characters of variety Varuna.

Fig 40. General numerical characters of variety Rohini.



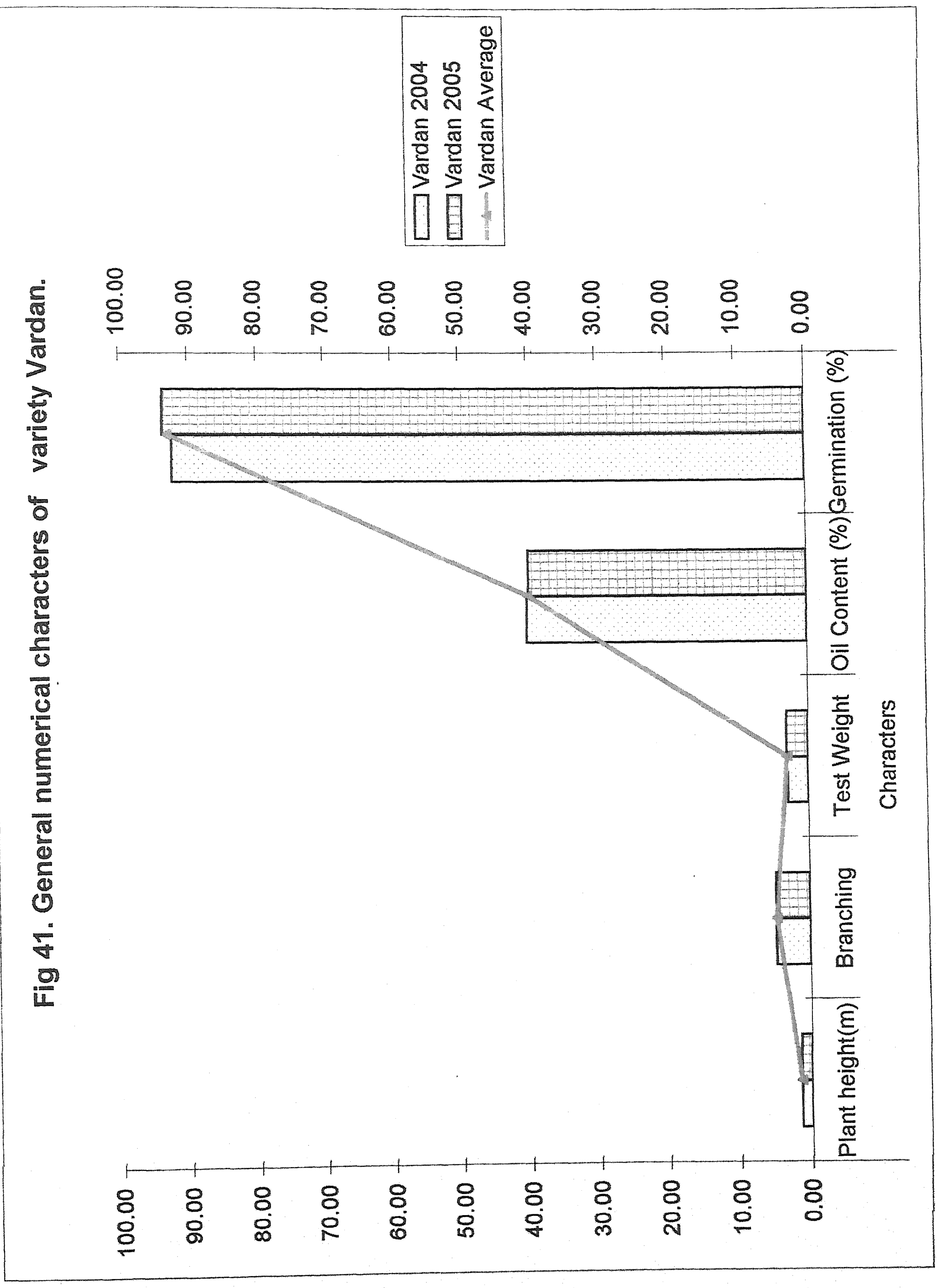


Fig 41. General numerical characters of variety Vardan.

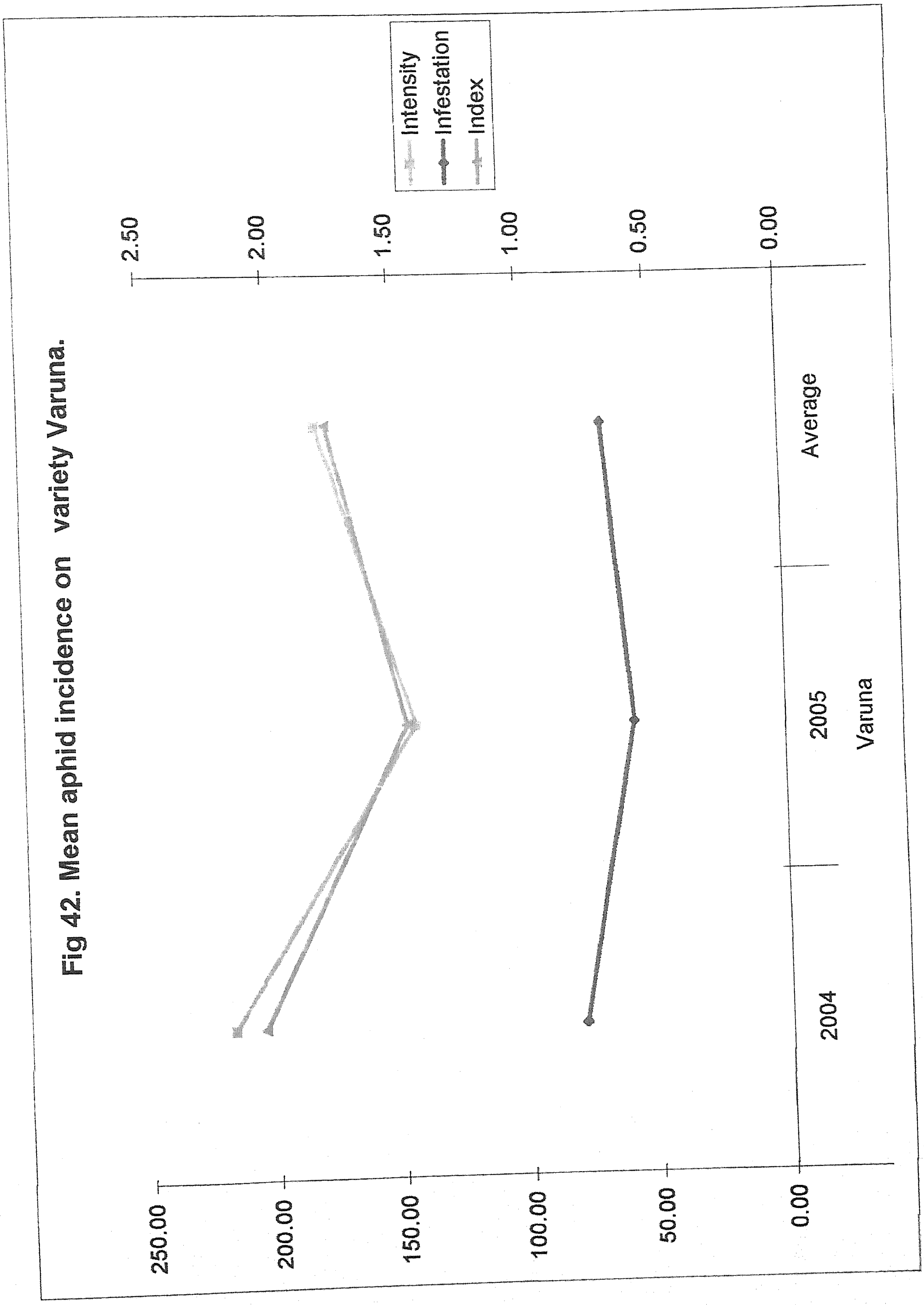


Fig 42. Mean aphid incidence on variety Varuna.

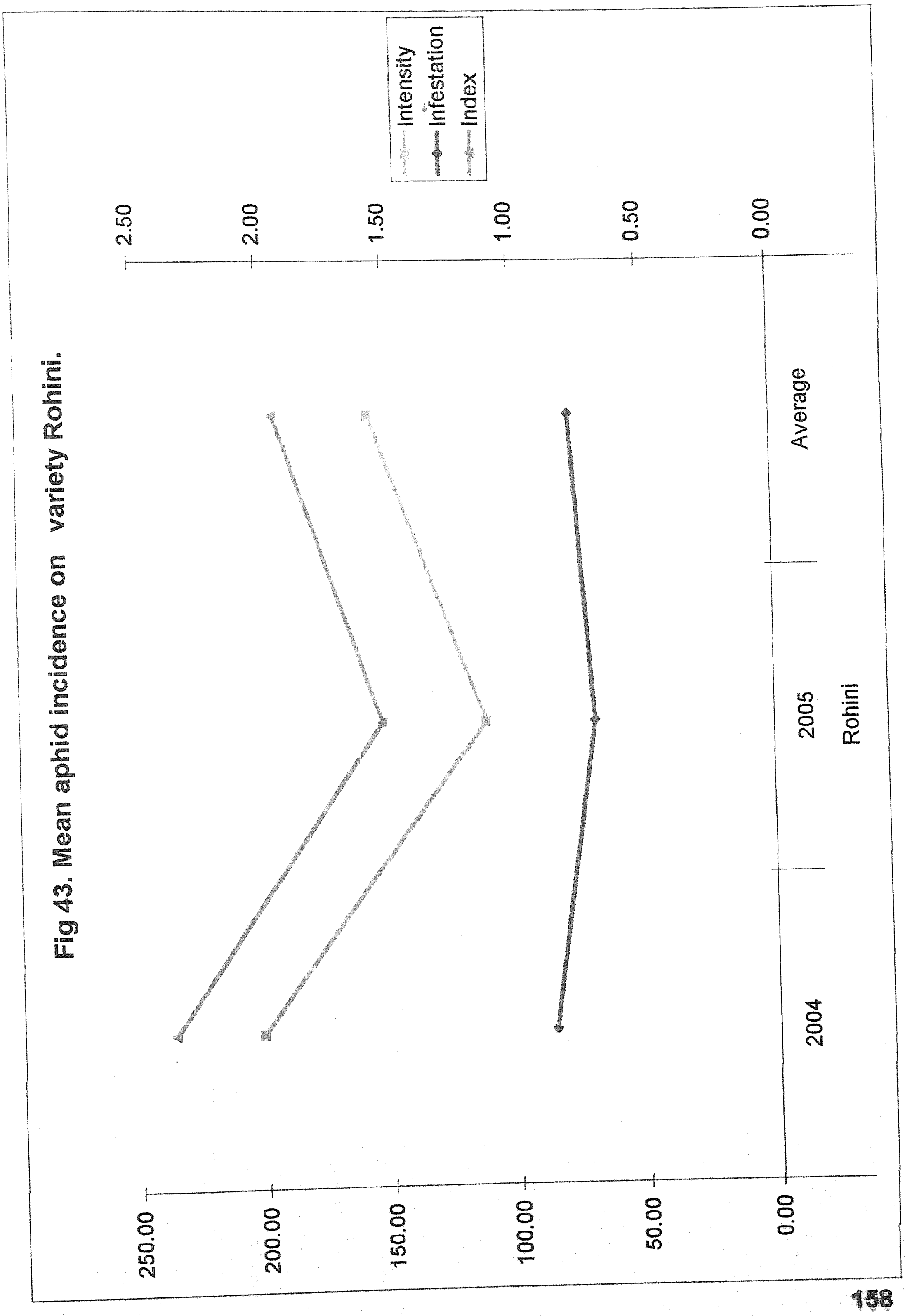


Fig 43. Mean aphid incidence on variety Rohini.

Fig 44. Mean aphid incidence on variety Vardan.

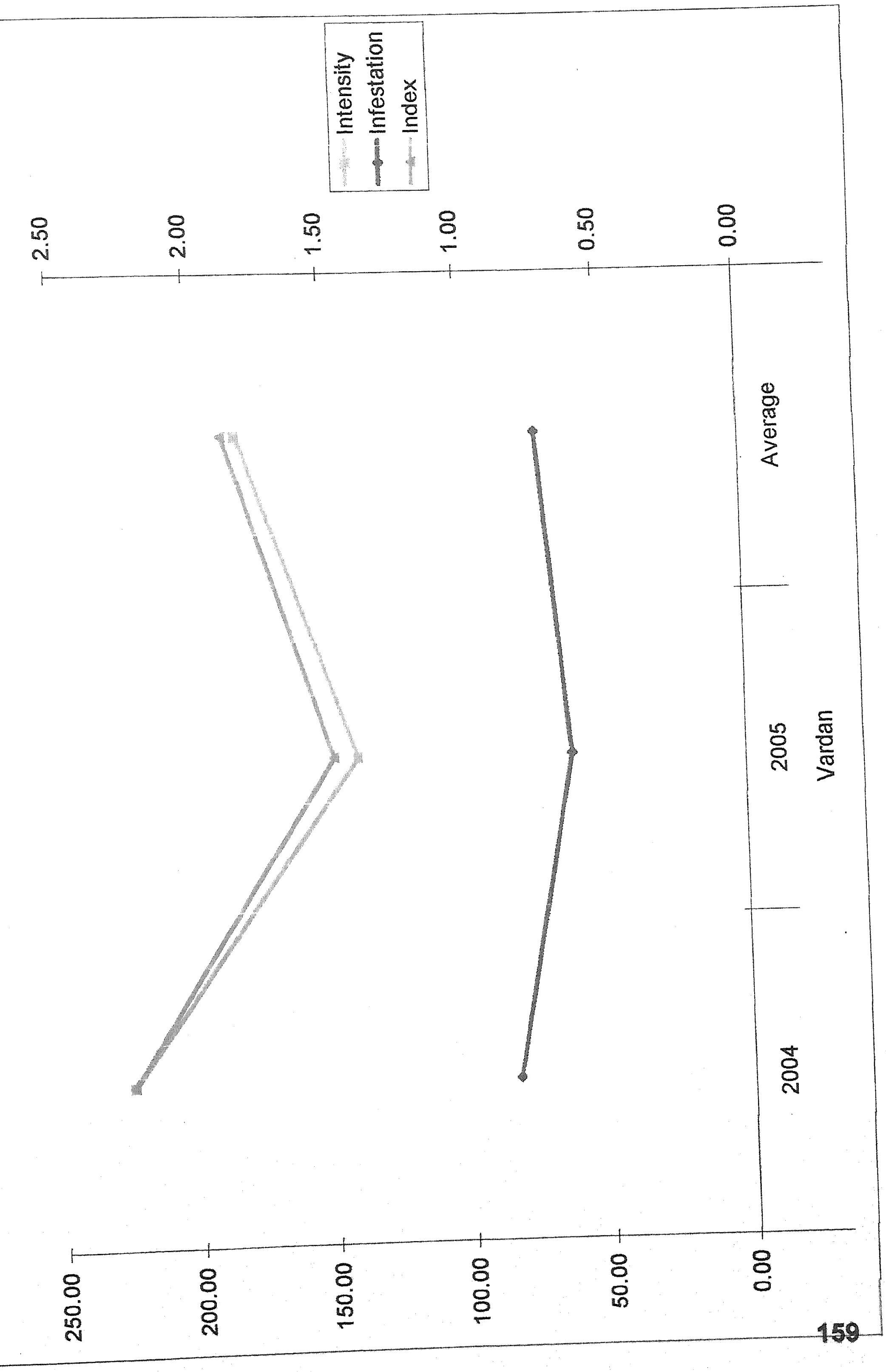


Fig 45. Effect of insecticidal treatments on different physical charcters of aphid population on Varuna during 2004.

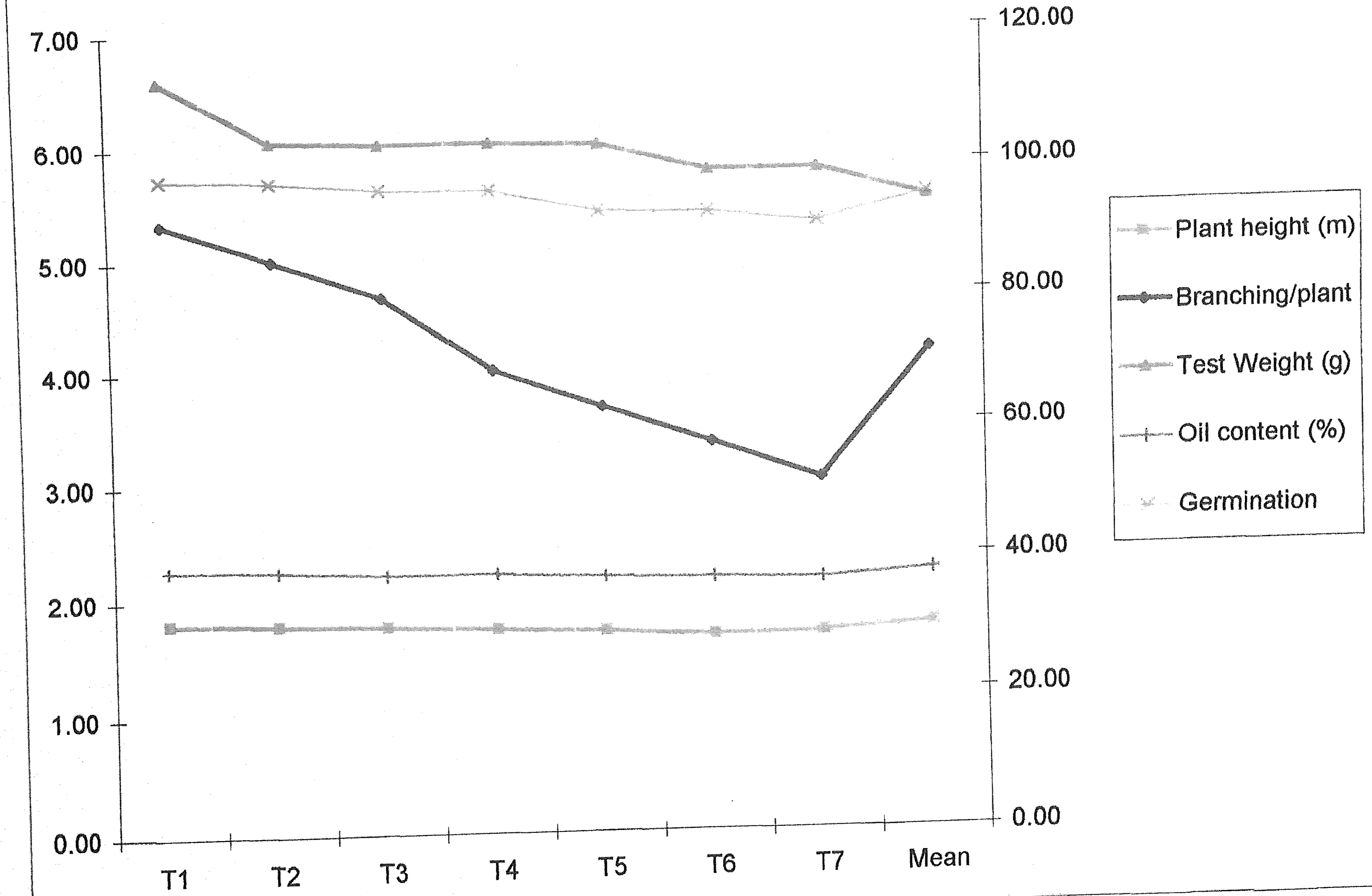


Fig 46. Effect of insecticidal treatments on intensity,infestation and index on aphid population on Varuna during 2004.

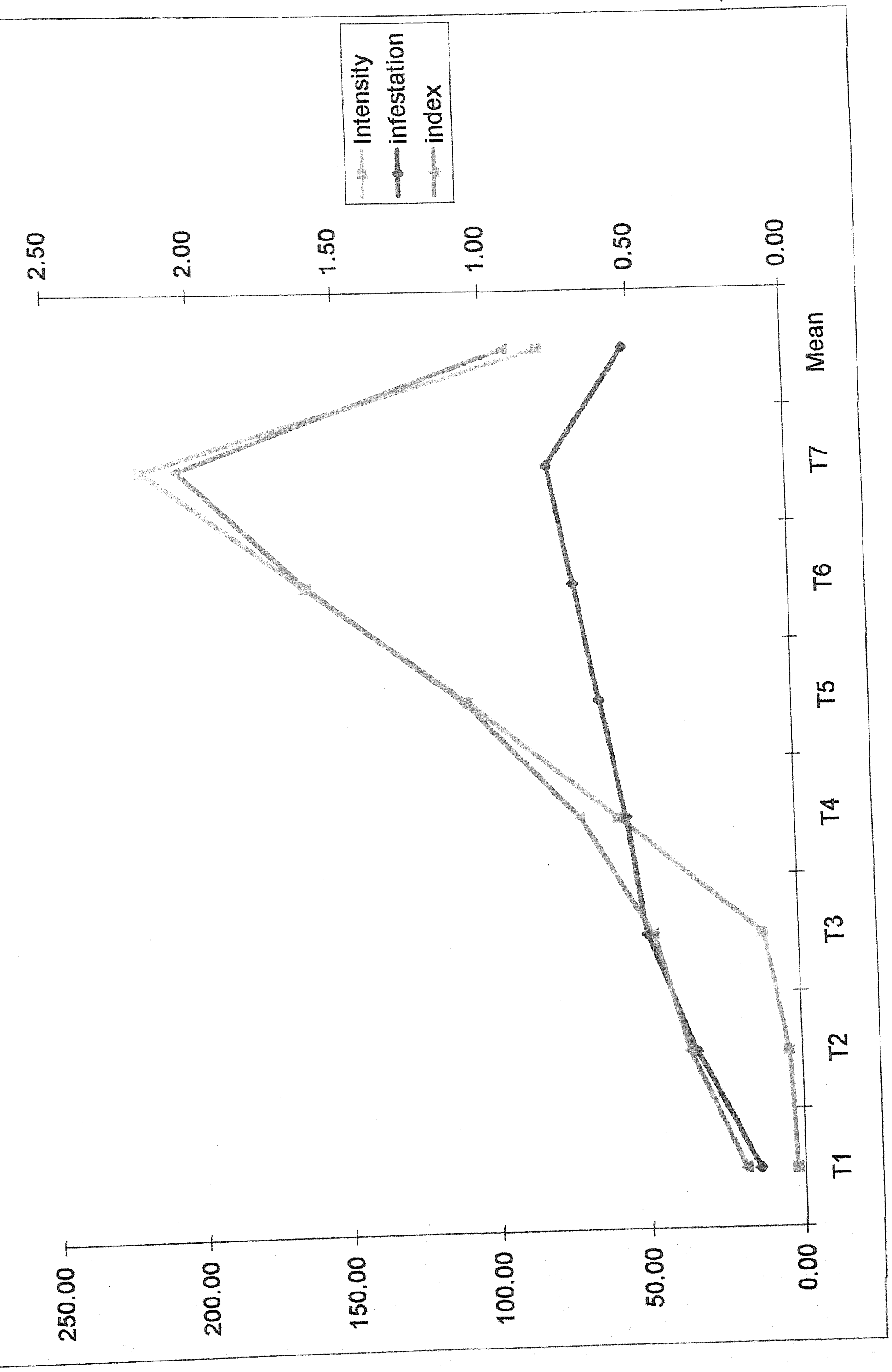


Fig 47. Effect of insecticidal treatments on different physical charcters of aphid population on Rohini during 2004.

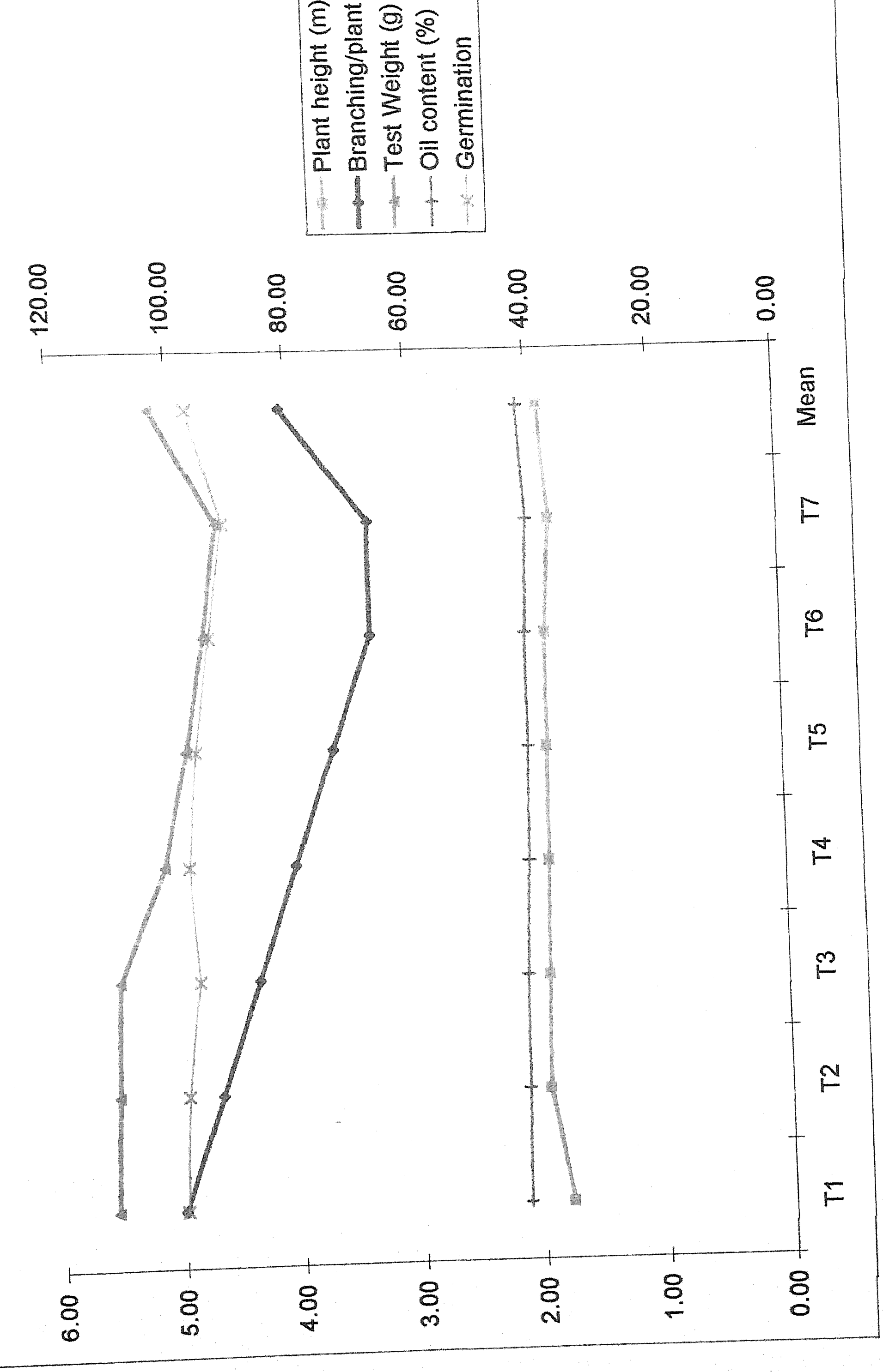
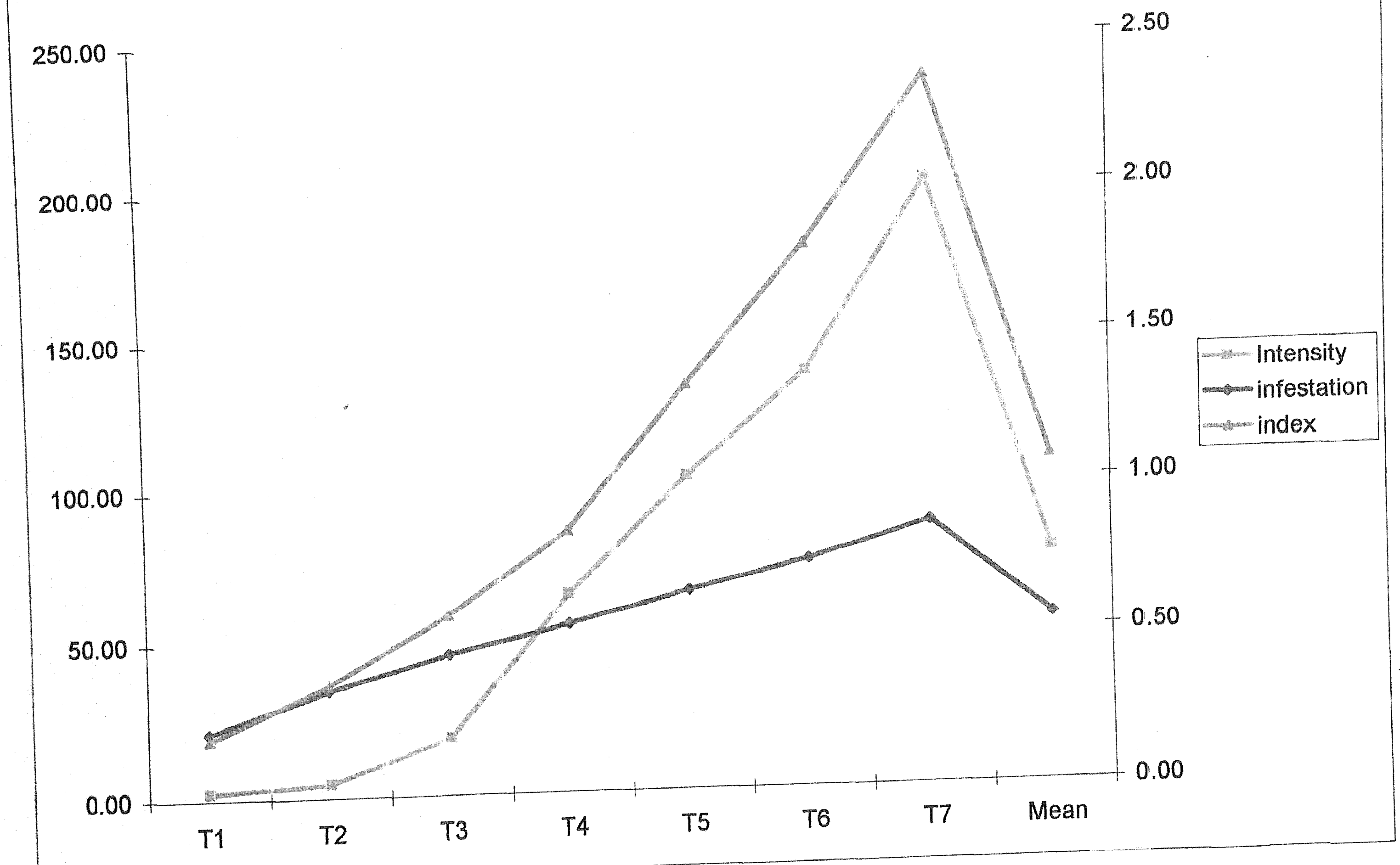


Fig 48. Effect of insecticidal treatments on intensity,infestation and index on aphid population on Rohini during 2004.



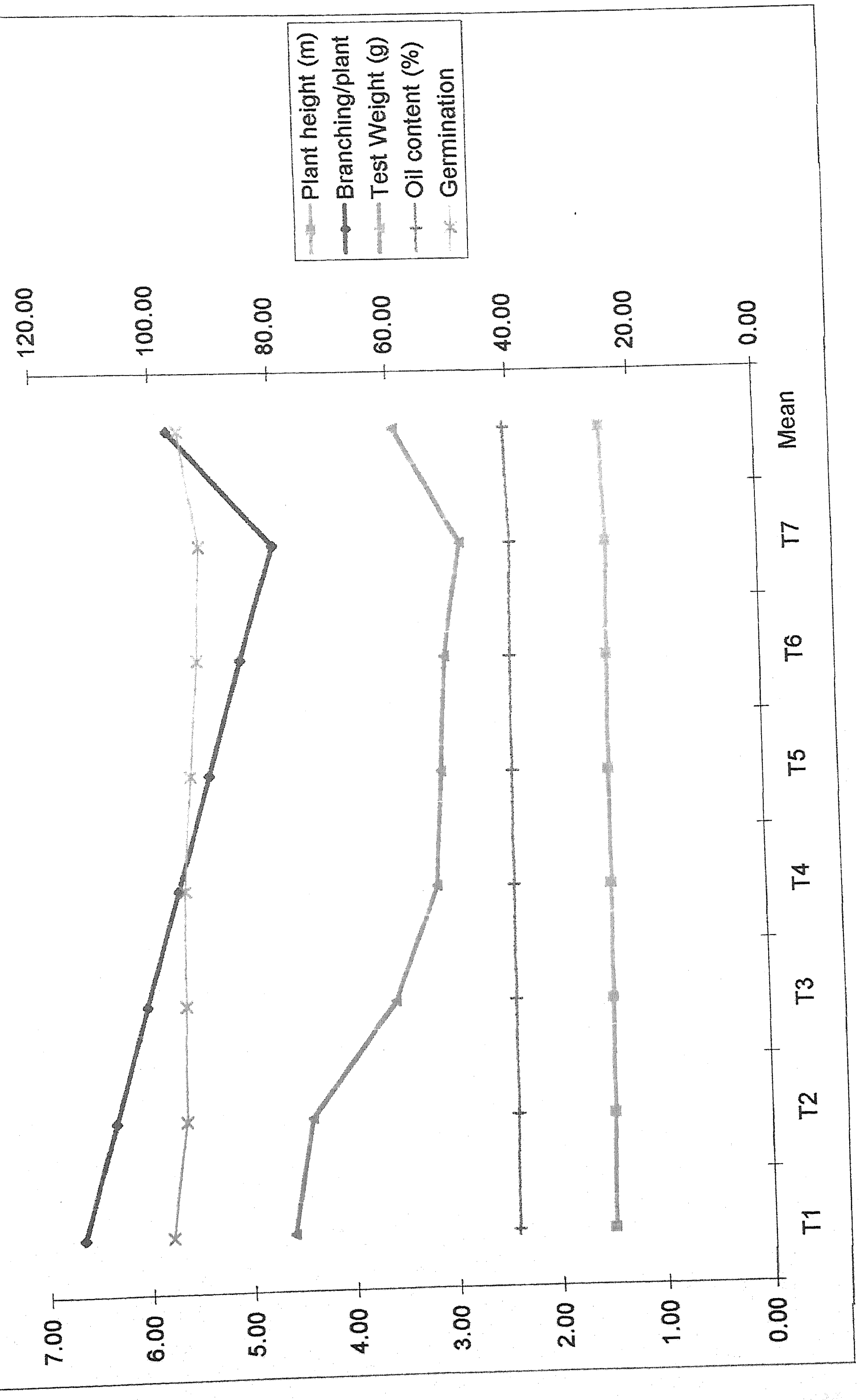
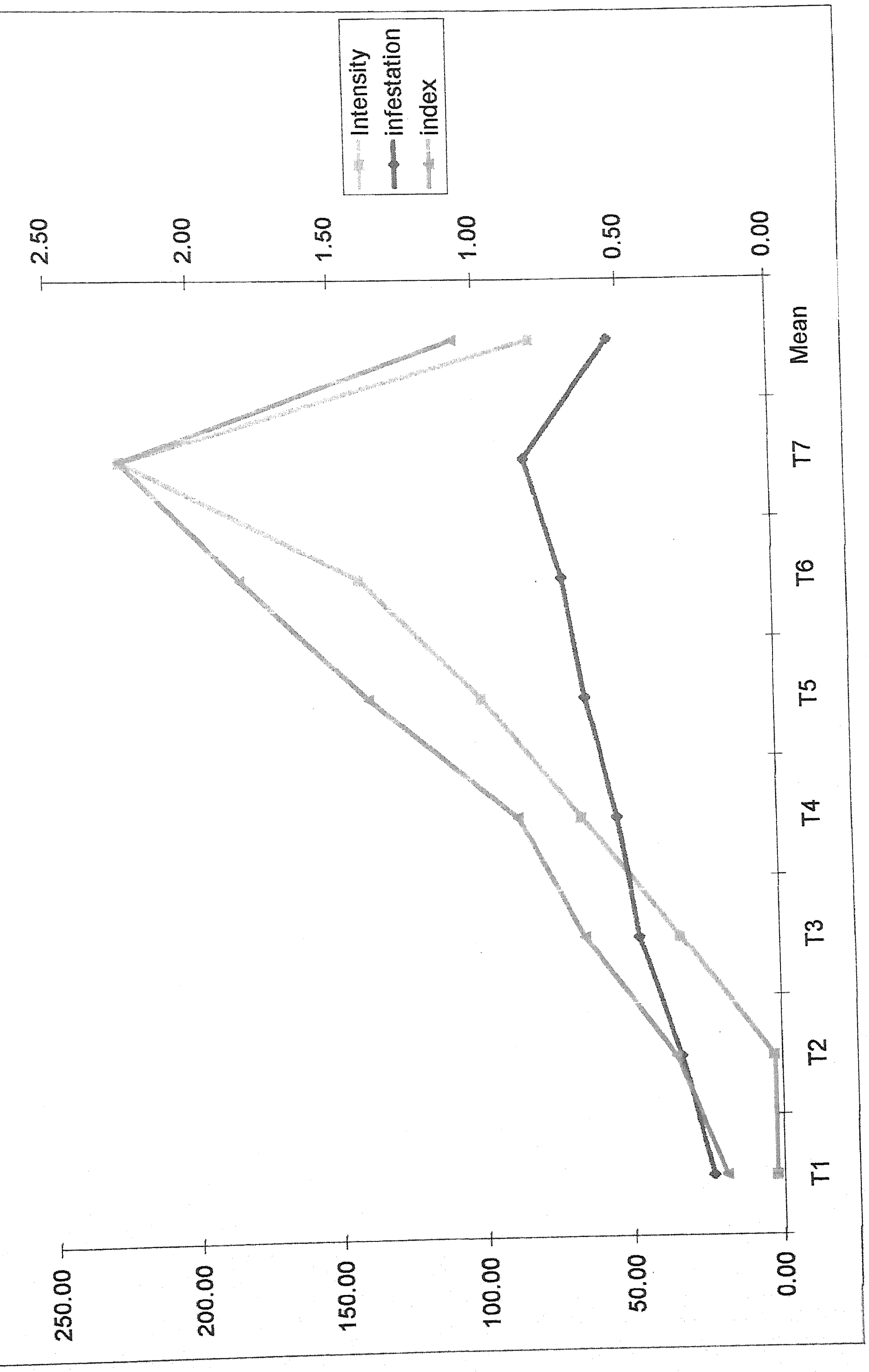


Fig 49. Effect of insecticidal treatments on different physical charcters of aphid population on Vardan during 2004.

Fig 50. Effect of insecticidal treatments on intensity,infestation and index on aphid population on Vardan during 2004.



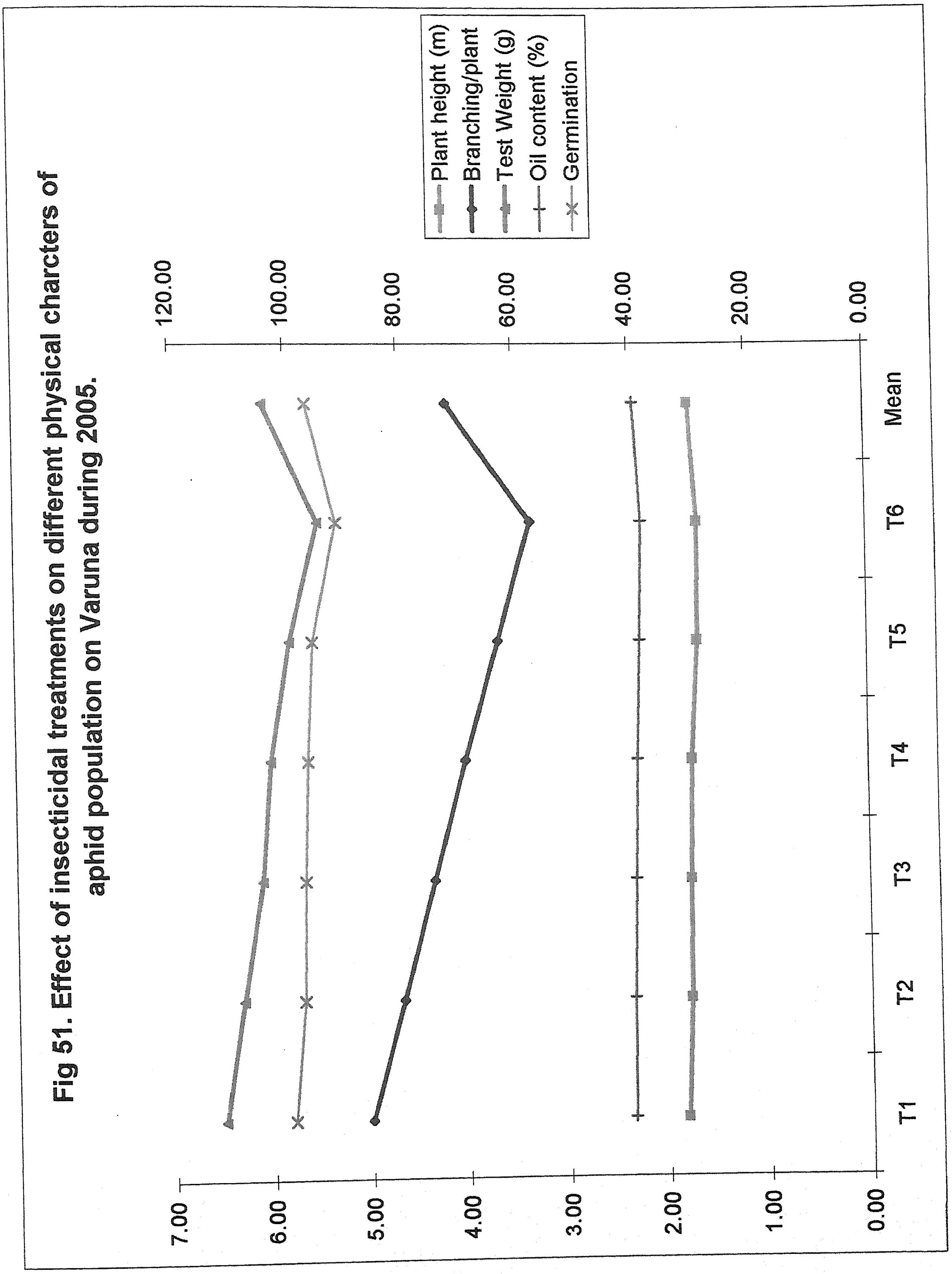
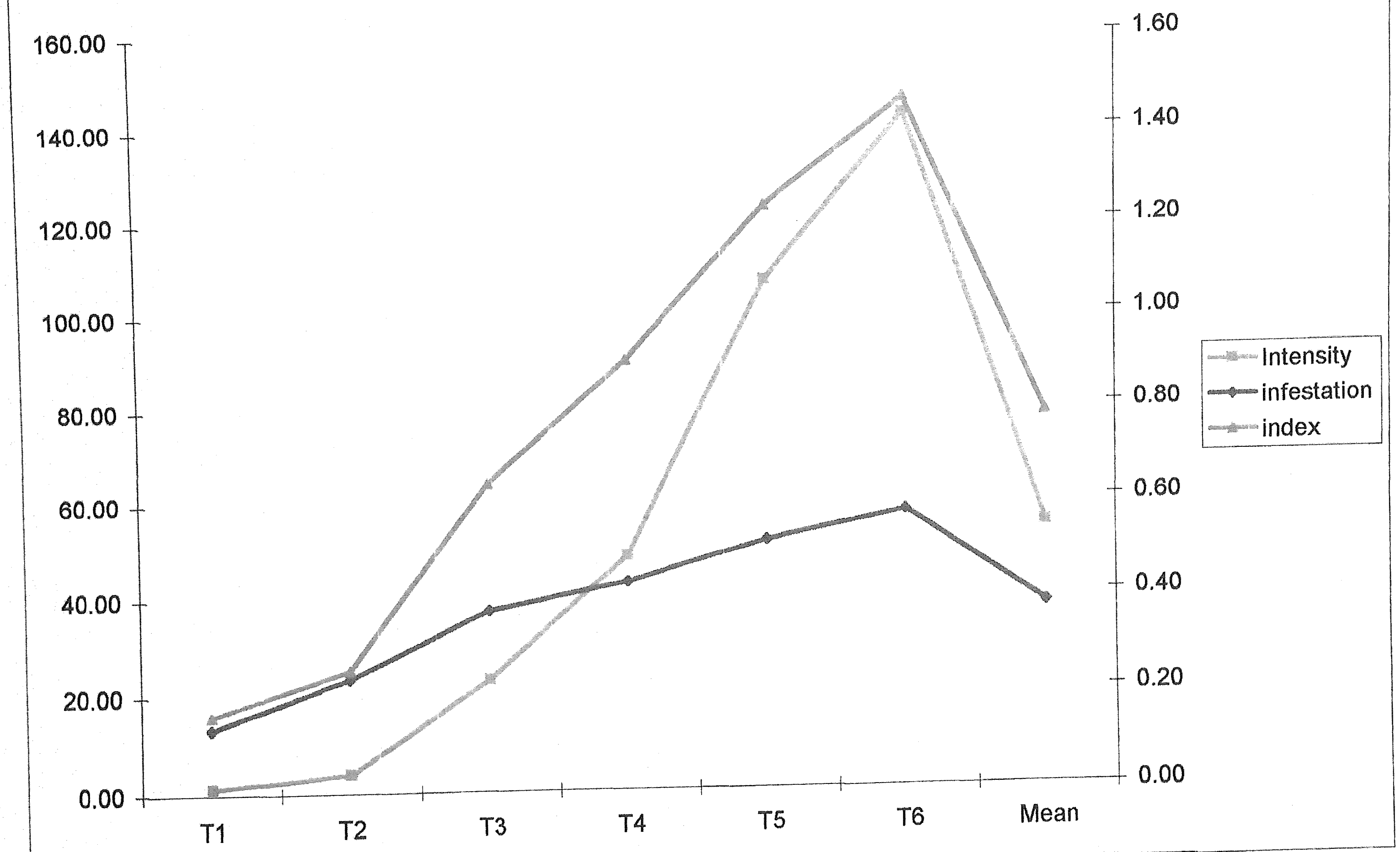


Fig 51. Effect of insecticidal treatments on different physical chracters of aphid population on Varuna during 2005.

Fig 52. Effect of insecticidal treatments on intensity,infestation and index on aphid population on Varuna during 2005.



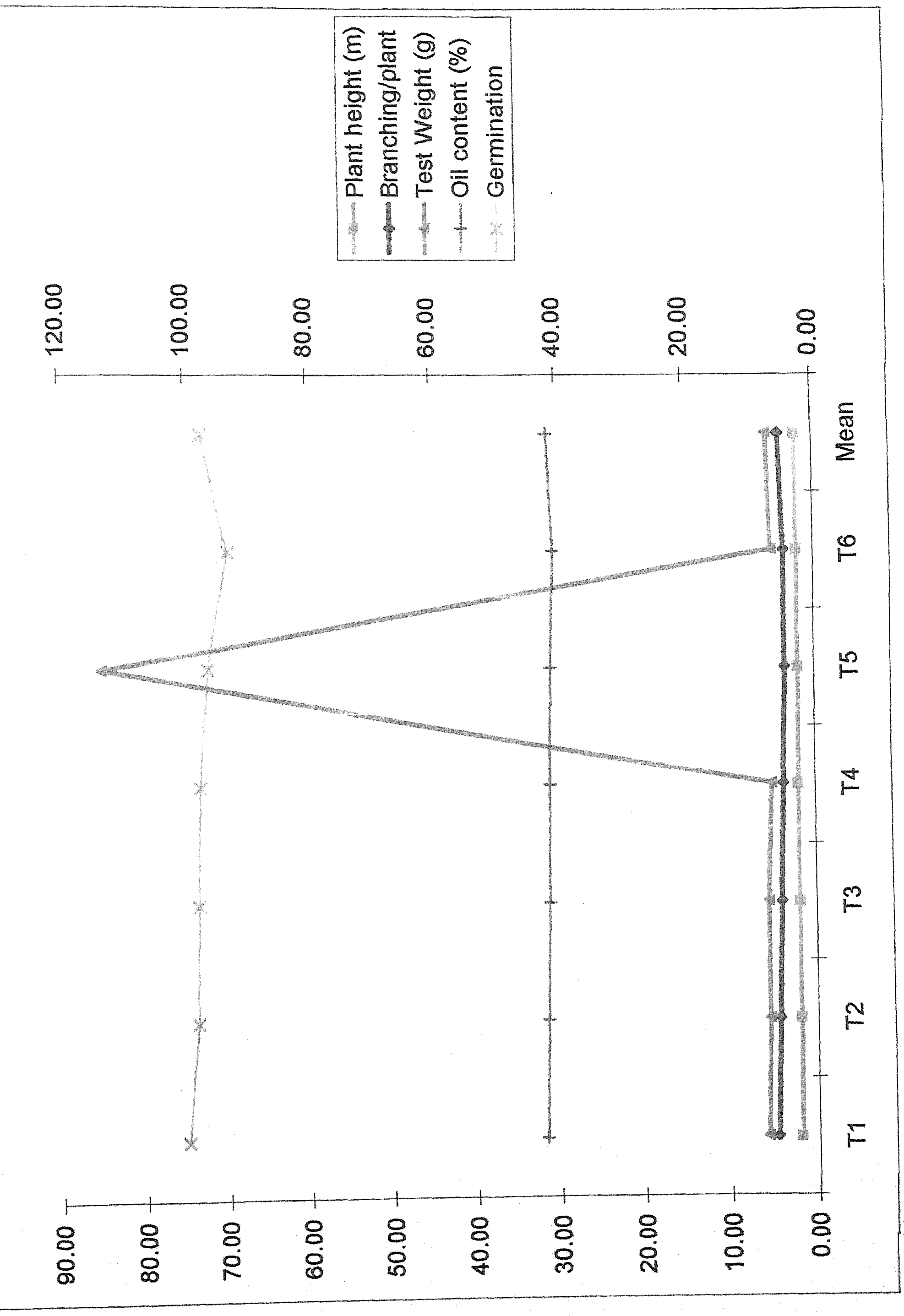


Fig 53. Effect of insecticidal treatments on different physical charcters of aphid population on Rohini during 2005.

Fig 54. Effect of insecticidal treatments on intensity,infestation and index on aphid population on Rohini during 2005.

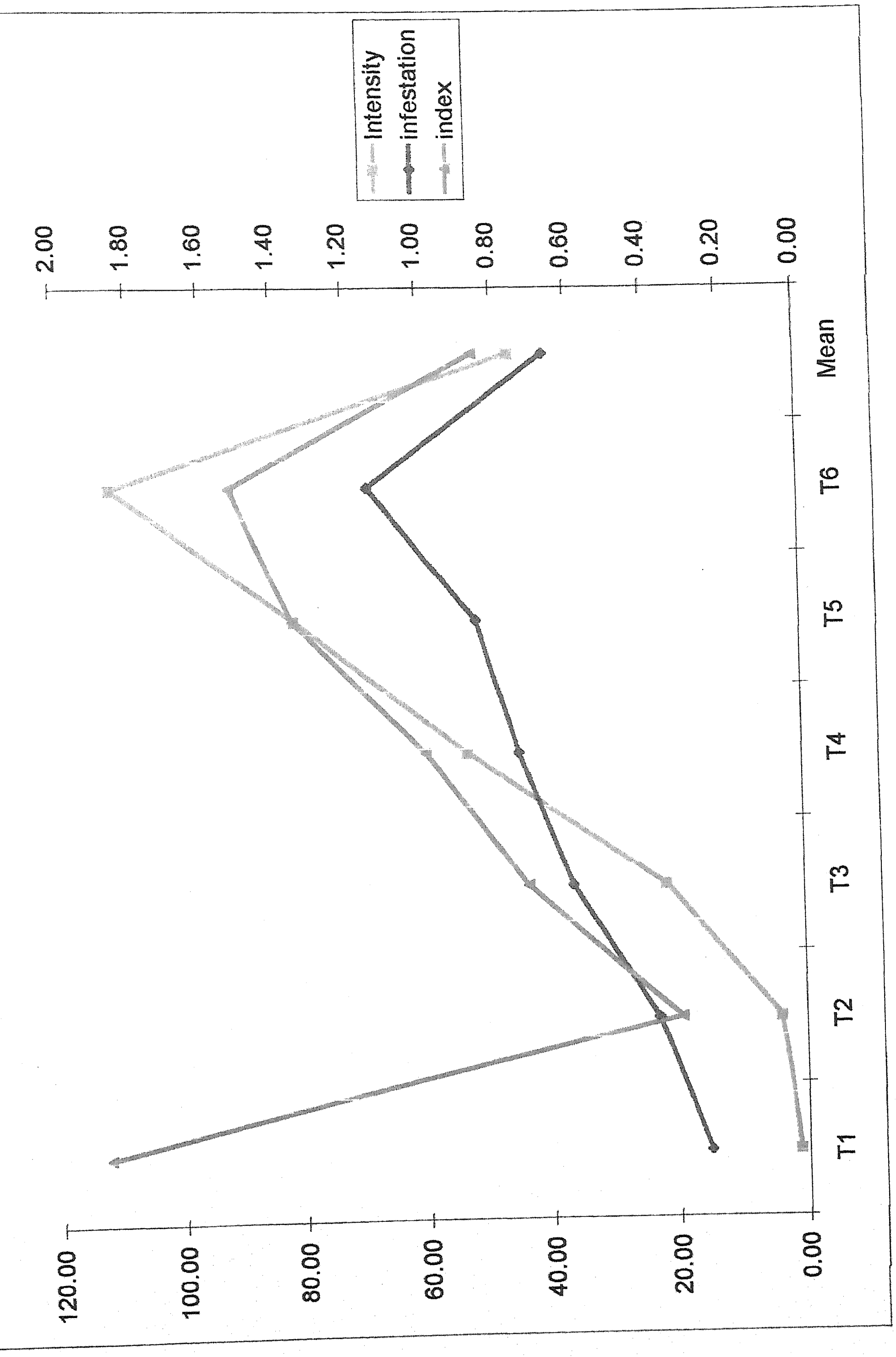


Fig 55. Effect of insecticidal treatments on different physical charcters of aphid population on Vardan during 2005.

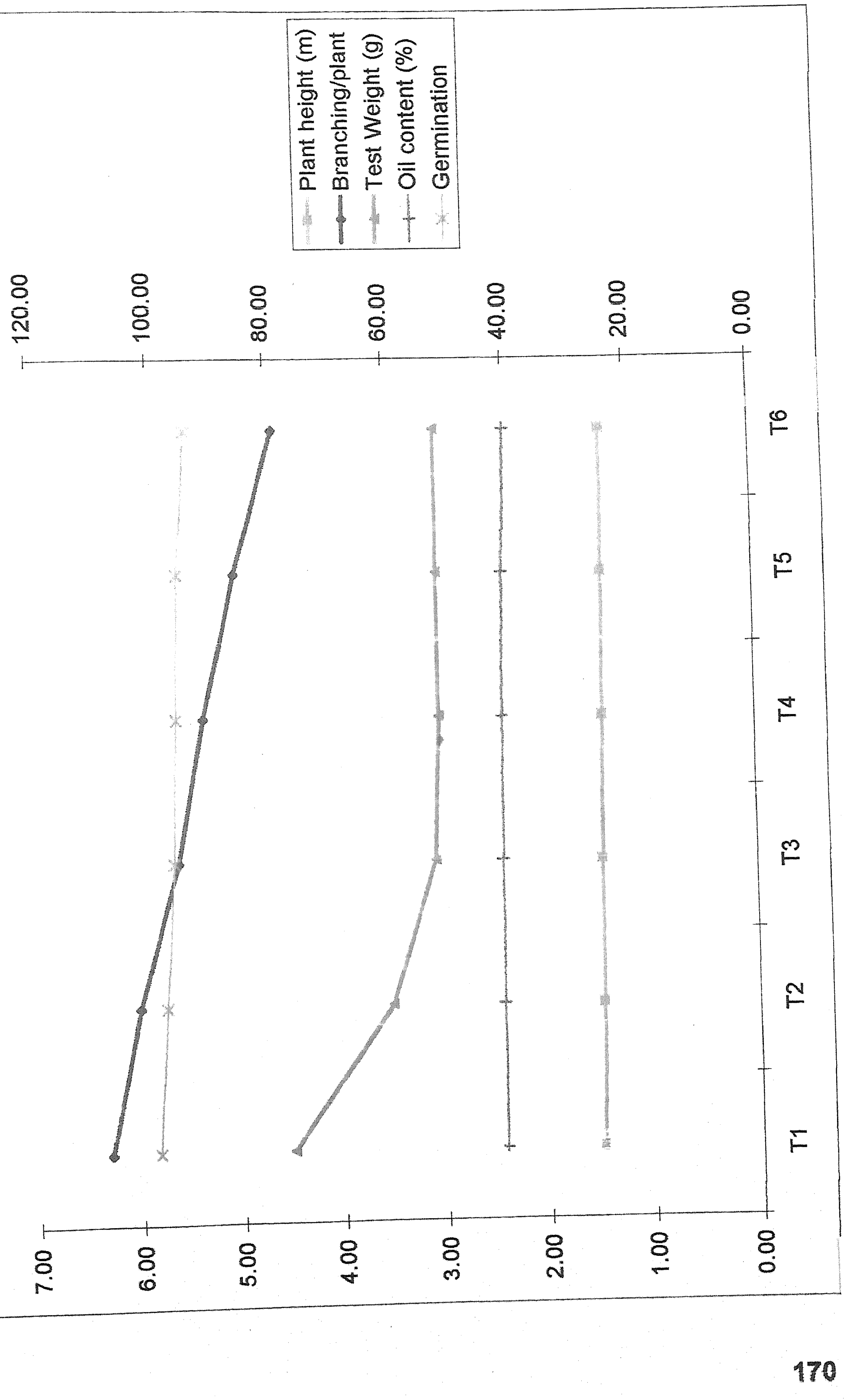
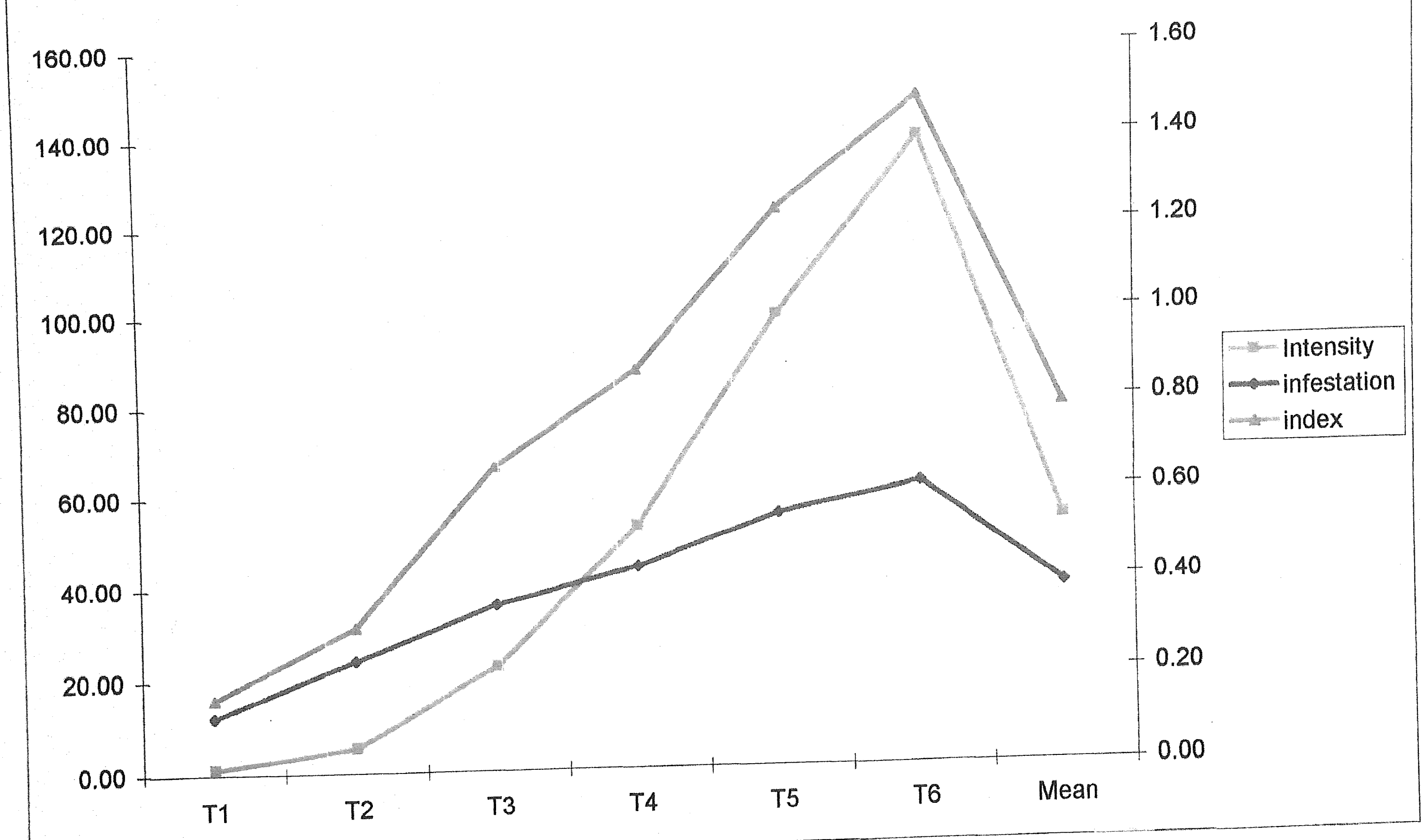


Fig 56. Effect of insecticidal treatments on intensity,infestation and index on aphid population on Vardan during 2005.



phosphamidon to a level of 1.80 and 1.81 m at which these were only 2.11 and 1.25 aphids per plant with a infestation level of 14.28 and 13.33 per cent and aphid infestation indices 0.19 and 0.16 against 217.40 and 0.16 against and 142.64; 78.57 and 57.22 per cent and 2.05 and 1.46 in untreated control plots on variety Varuna respectively during subsequent years (Table 49 to 54). Variety Rohini also responded in a similar fashion as its plant height increased from 1.83 to 1.79 and 1.96 m during subsequent years at which aphid intensity, infestation and infestation indices were 201.16 and 110.86, 85.71 and 68.33 per cent and 2.36 and 1.52 in untreated control plants Similarly, Vardan had shown enhancement in plant height from 1.41 to 1.49 m during first year and 1.40 to 1.48 m during second year experiment. The aphid incidence of 2.22 aphids per plant with an infestation of 23.33 per cent and its index of 0.19 in the protected plots, respectively, during 2003-2004 (Table 49 to 51) while respective figures during 2004-2005 were 1.12, 12.22 and 0.16 in treated and 139.0, 61.11 per cent and 1.48 in untreated control plots (Table 52 to 54)

(II) Branching :

The normal number of branches were 31.6 on vardan, 3.33 on Rohini and 4.63 on Vardan which were found to be influenced by insecticidal treatments on all the three varieties but significantly maximum 6.66 and 6.30 were recorded on Vardan followed by 5.33 and 5.00 on Varuna and least 5.00 and 4.66 on Rohini during subsequent years (Table

[illegible]). There was minimum intensity, infestation and index of aphids on the completely protected plots having maximum branching, whereas highest in untreated control plots having only 4.66 and 4.60 branches on Vardan, 3.00 and 3.33 on Varuna and 3.33 and 3.33 on Rohini during consecutive years.

(III) Test Weight :

The normal test weights of 5.50, 4.70 and 2.92 g were significantly distinct on Varuna, Rohini and Vardan without any treatment (Table 46, 47 & 48). It was found to be increased with the protection of the crop from aphid by continuous insecticidal sprays. There was enhancement from 5.50 to 6.60 g on Varuna, 4.60 - 5.50 and 4.80-5.53 g on Rohini and 2.83-4.60 and 3.00 – 4.50 g on Vardan during respective years (Table 49 to 54).

(IV) Oil Content:

The oil content was 40.48 and 40.00 per cent of Rohini and Vardan were higher than those of Varuna 37.30 per cent the oil contents could significantly be increased by insecticidal treatments and were recorded to be as high as 36.50-38.87 and 37.00 to 40.10 per cent in Varuna, 40.46-42.50 and 40.50-42.20 in Rohini and 40.09-41.41 and 39.90-41.50 per cent on Vardan Varieties during subsequent years due to significant reduction in aphid intensity, infestation and indices (Table 46 to 54).

(V) <u>Germination</u> :

The average germination was significantly distinct being 90.83, 92.00 and 93.00 on Varuna, Rohini and Vardan, had been found to be improved by protection of crop it had increased from 90.66-92.33 and 90.00- 99.33 in Vardan, 91.00 - 99.66 and 93.00 per cent in Rohini and 92.33-99.33 and 93.66-100 per cent on Vardan during respective years, in the plots having the minimum intensity, infestation and indices of aphid (Table – 46 to 54).

A number of scientists including Prasad and Phadke (1980), Vir and Henry (1987), Singh and Yadav (1986), Taipur *et al.* (1991) and Raj *et al.* (1992) reported that different for aphid infestation than other species of rapeseed and mustard. According to Kumar (1990) specific combination ability variance of the Indian mustard parents and their hybrids were more significant for resistance parameters including size of the aphid colonies and per cent investigations, Varuna is also having lowest pest intensity, infestation and infestation indices that might be due to its inheritable characteristics of hairiness in the lower surface of the leaves and completion of flowering stage about 5 days earlier than the others. Some biochemicals including protein, sugar and oil contents at a high level shows susceptibility of aphid infestation in *Brassica juncea* (Sachan and Sachan, 1991). These observations also confirm the present 40.00 per cent in Vardan and 40.48 per cent in Rohini. Contrary to it, lower number of branches (3.16 per cent) with highest test weight 5.50 g

in Varuna, having clustered yellow flowers and non appress siliquae may contribute for resistance in this variety in comparison to Rohini and Vardan, which were having more number of branches 3.33 and 4.63, lesser test weight 4.70 and 2.92 g and elongated and clustered receme. Though the viability of the seeds based on germination percentage was 93.00 in Vardan, 92.00 in Rohini and 93.83 per cent in Varuna. Singh et al (19..) indicated petalous characters pay a dominant role over apetalous characters governed by two duplicate genes in mustard varieties including Varuna and RH-39. the resistance characters can be transmitted to the off-spring by complete diallel cross (Yadav et al. 199.), but as per the results of present findings, the plant characteristics like plant height, branching, test weight, oil content and germination etc. can significantly be improved by reducing the attack of aphid *L. erysimi* on these varieties through the use of protection technology. It can be argued that aphid infestation is responsible for reducing treatment varieties. Such efforts have also been made by Singh and Singh (1989) to explore the plant growth through insecticidal treatments.

6. ASSESSMENT OF ECONOMIC DAMAGE:

The experiments conducted during 2003-2004 and 2004-2005 determine economic injury level, economic threshold and extent of losses by creating varying insecticidal pressures through varying application of phosphamidom (85 SL) @ 0.03% spray in different treatments (Table 55 to 60). The mean aphid intensity infestation and indices prevailing in these

TABLE - 55

Relationship of aphid population and yield of mustard for variety Varuna during 2004.

Treatment	Aphid population				Relationship of various parameters
	Intensity	infestation (%)	index	Yield (kg/ha)	
T_1	2.11	18.56	0.19	1643	(I) Intensity(X) Vs Yield (Y_3)
T_2	4.42	33.80	0.35	1539	Y=1532.595-1.67X.
T_3	7.25	49.04	0.47	1481	(II) Intensity(X) Vs Infestation (Y_1)
T_4	57.64	54.75	0.69	1354	Y=34.1522+0.207X
T_5	107.00	62.85	0.08	1307	(III) Intensity(X) Vs Infestation index(Y_2)
T_6	161.65	70.47	1.60	1255	
T_7	231.68	78.56	2.09	1190	Y=0.2873+0.0078X
Mean	**81.68**	**52.57**	**0.92**	**1396**	

TABLE - 56

Relationship of aphid population and yield of mustard for variety Rohini during 2004.

Treatment	Aphid population				Relationship of various parameters
	Intensity	infestation (%)	index	Yield (kg/ha)	
T_1	2.13	21.42	0.18	1689	(I) Intensity(X) Vs Yield (Y_3)
T_2	5.49	34.28	0.37	1562	Y=1561.764-1.6964X.
T_3	19.88	45.23	0.58	1493	(II) Intensity(X) Vs Infestation (Y_1)
T_4	43.29	54.29	0.84	1377	Y=33.5568+0.2812X
T_5	102.38	63.80	1.32	1330	(III) Intensity(X) Vs Infestation index(Y_2)
T_6	135.25	73.80	1.82	1265	
T_7	201.16	85.70	2.36	1250	Y=0.3028+0.0105X
Mean	**72.79**	**54.06**	**1.06**	**1424**	

TABLE - 57

Relationship of aphid population and yield of mustard for variety Vardan during 2004

Treatment	Aphid population			Yield (kg/ha)	Relationship of various parameters
	Intensity	infestation (%)	index		
T_1	2.20	23.33	0.19	2358	(I) Intensity(X) Vs Yield (Y_3)
T_2	5.61	33.37	0.35	2329	Y=2332.5482-2.0826X
T_3	32.99	46.66	0.64	2298	(II) Intensity(X) Vs Infestation (Y_1)
T_4	65.29	43.32	0.87	2194	Y=31.1425+0.2568X
T_5	98.98	63.33	1.37	1988	(III) Intensity(X) Vs Infestation index(Y_2)
T_6	140.73	70.47	1.83	1980	
T_7	214.96	81.52	2.25	1970	Y=0.2864+0.0098X
Mean	**80.11**	**51.71**	**1.07**	**2161**	

TABLE - 58

Relationship of aphid population and yield of mustard for variety Varuna during 2005

Treatment	Aphid population			Yield (kg/ha)	Relationship of various parameters
	Intensity	infestation (%)	index		
T_1	1.01	13.33	0.16	1990	(I) Intensity(X) Vs Yield (Y_3)
T_2	3.94	23.32	0.29	1916	Y=1907.8623-1.8820X.
T_3	22.98	37.76	0.63	1854	(II) Intensity(X) Vs Infestation (Y_1)
T_4	48.30	42.83	0.89	1851	Y=23.7137+0.349X
T_5	106.94	84.44	1.22	1736	(III) Intensity(X) Vs Infestation index(Y_2)
T_6	142.64	54.44	1.46	1680	Y=0.7153+0.0011X
Mean	**54.30**	**42.69**	**0.77**	**1831**	

TABLE - 59

Relationship of aphid population and yield of mustard for variety Rohini during 2005.

Treatment	Aphid population			Yield (kg/ha)	Relationship of various parameters
	Intensity	infestation (%)	index		
T_1	1.04	14.99	0.18	1851	(I) Intensity(X) Vs Yield (Y_3)
T_2	3.40	23.33	0.31	1816	Y=1671.38-2.1459X.
T_3	20.02	35.55	0.71	1712	(II) Intensity(X) Vs Infestation (Y_1)
T_4	50.88	43.33	0.96	1689	Y=22.0027+0.3459X
T_5	81.44	49.10	1.34	1643	(III) Intensity(X) Vs Infestation index(Y_2)
T_6	110.94	58.32	1.52	1585	Y=0.3102+0.0118X
Mean	**44.62**	**37.44**	**0.84**	**1716**	

TABLE - 60

Relationship of aphid population and yield of mustard for variety Vardan during 2005

Treatment	Aphid population				Relationship of various parameters
	Intensity	infestation (%)	index	Yield (kg/ha)	
T_1	1.12	12.21	0.16	2200	(I) Intensity(X) Vs Yield (Y_3)
T_2	5.30	23.88	0.62	2108	Y=2111.272-2.4903X.
T_3	22.33	36.10	0.65	1970	(II) Intensity(X) Vs Infestation (Y_1)
T_4	52.30	43.32	0.87	1940	Y=21.9202+0.3035X
T_5	99.06	51.76	1.22	1855	(III) Intensity(X) Vs Infestation index(Y_2)
T_6	139.03	61.05	1.48	1800	Y=0.4078+0.0080X
Mean	**53.15**	**38.05**	**0.83**	**1979**	

Fig 57. Effect of insecticidal treatments on intensity,infestation, index and yield on aphid population on Varuna during 2004.

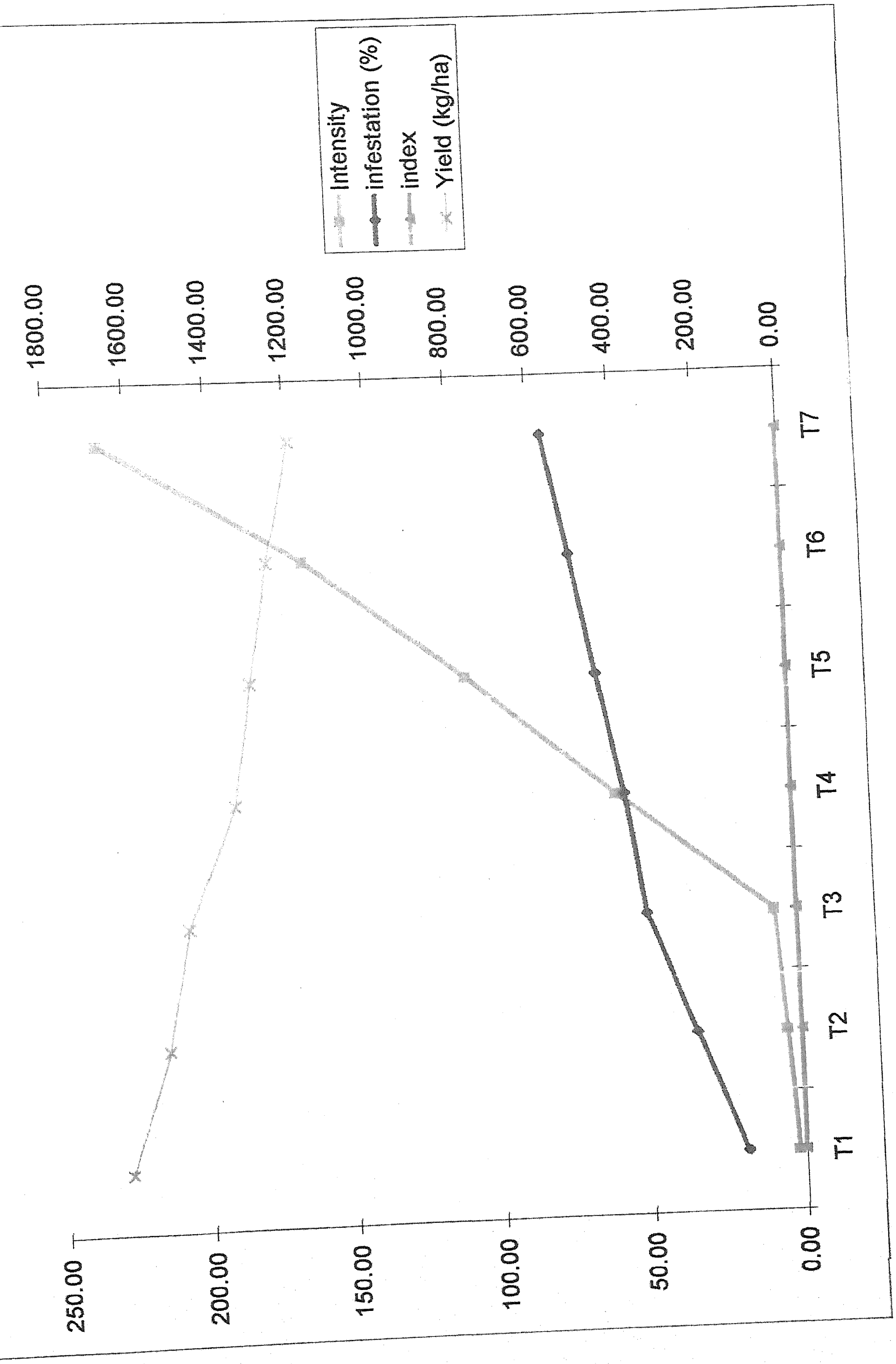


Fig 58. Effect of insecticidal treatments on intensity,infestation, index and yield on aphid population on Varuna during 2004.

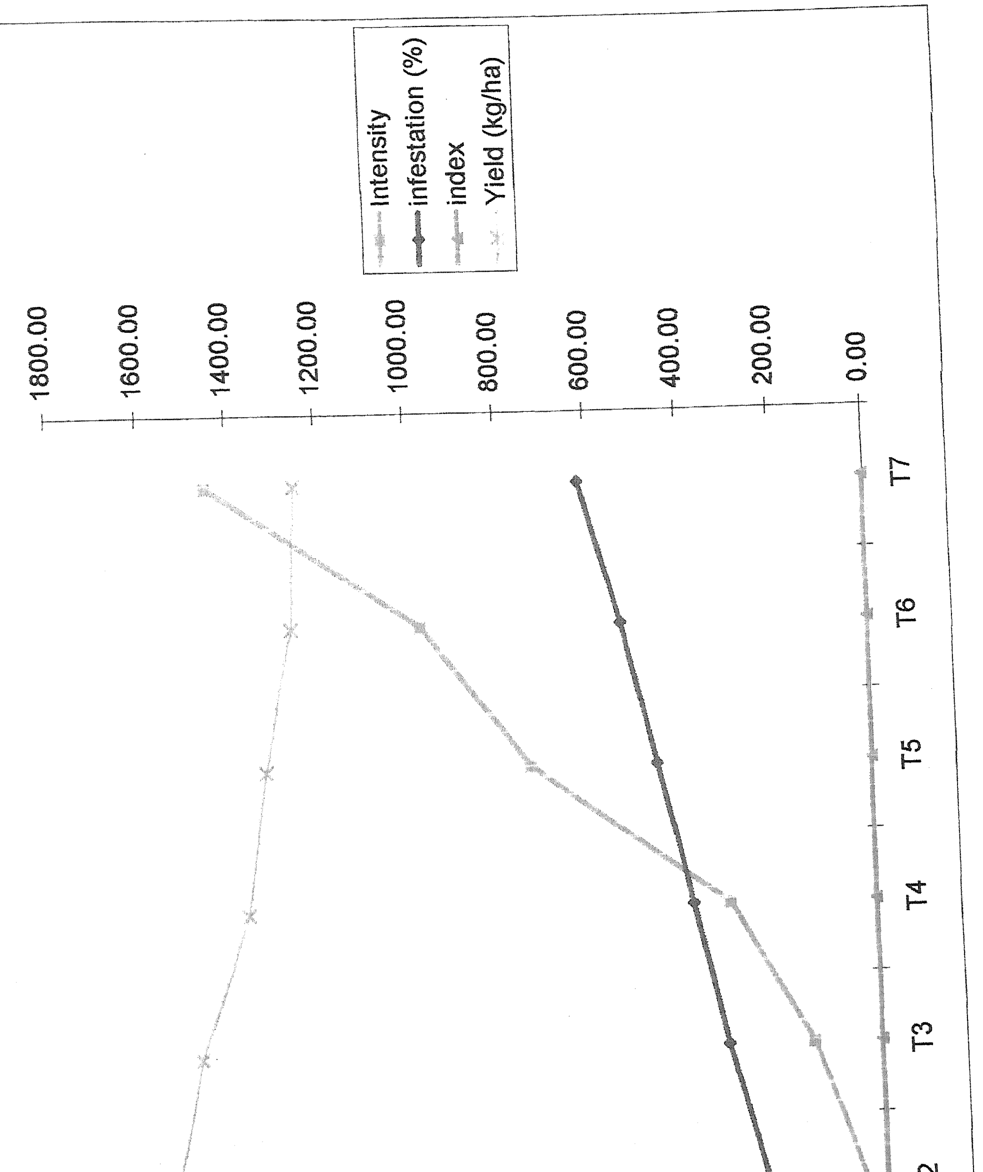
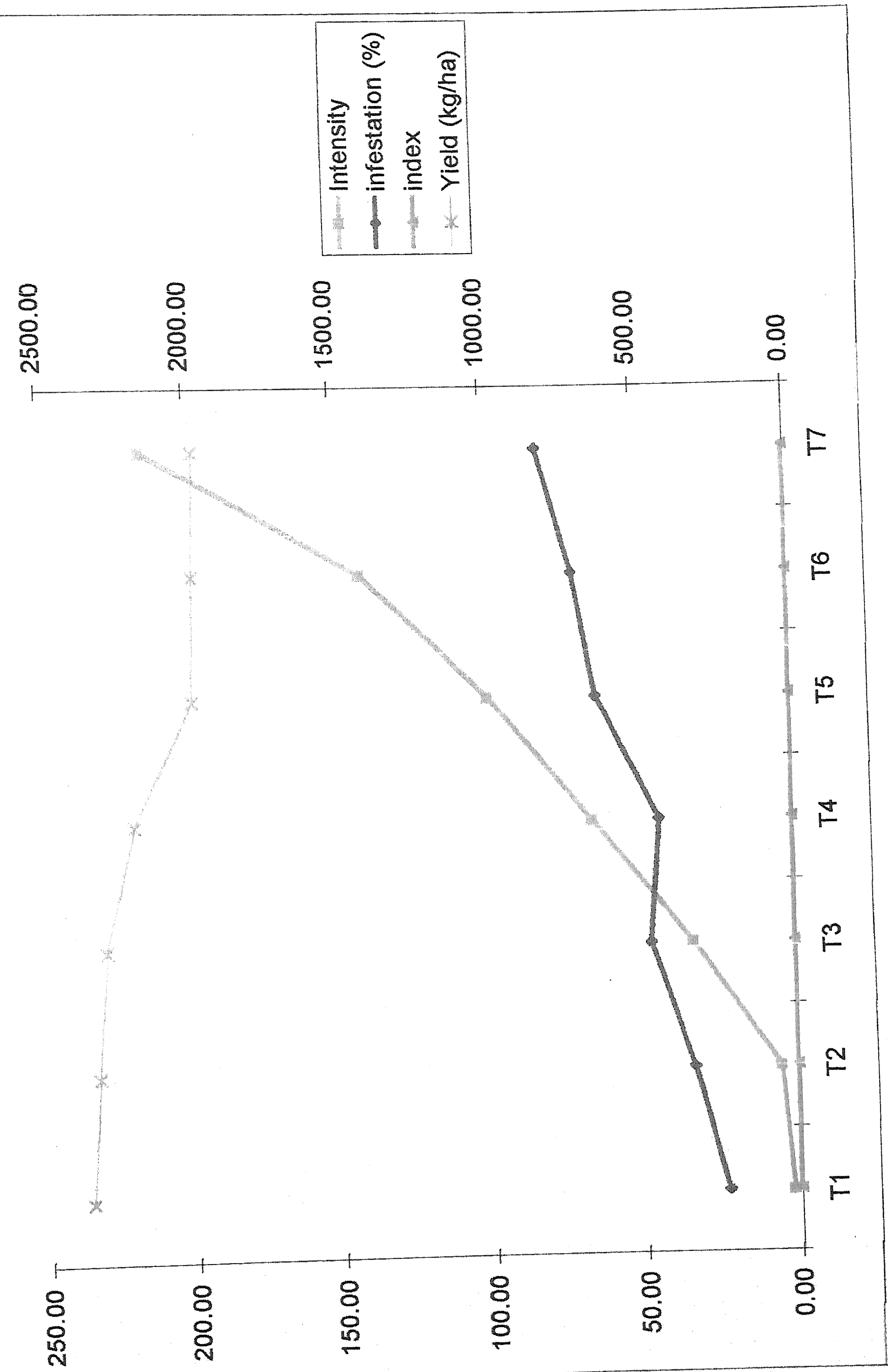


Fig 59. Effect of insecticidal treatments on intensity,infestation, index and yield on aphid population on Varuna during 2004.



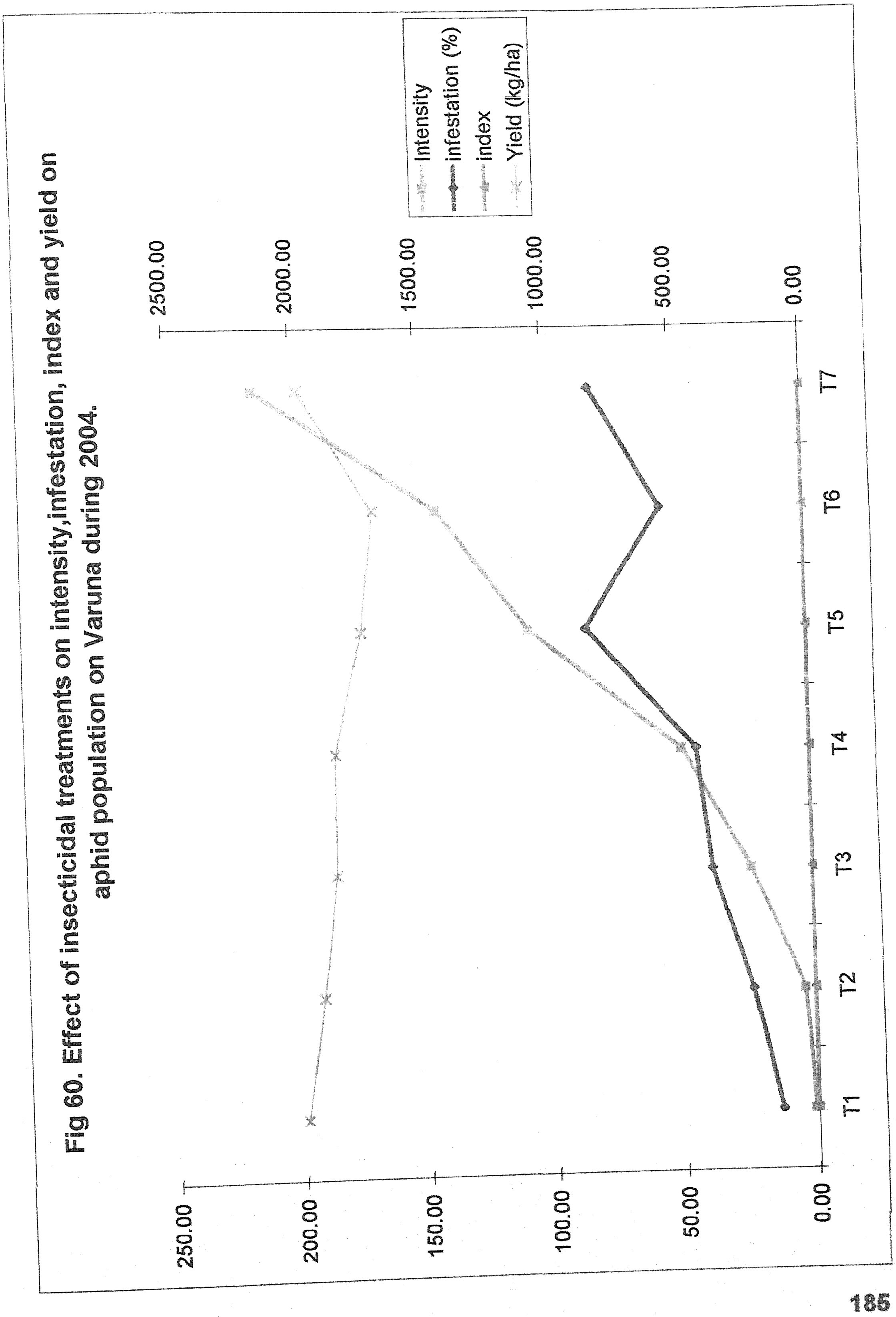


Fig 60. Effect of insecticidal treatments on intensity,infestation, index and yield on aphid population on Varuna during 2004.

Fig 61. Effect of insecticidal treatments on intensity,infestation, index and yield on aphid population on Varuna during 2004.

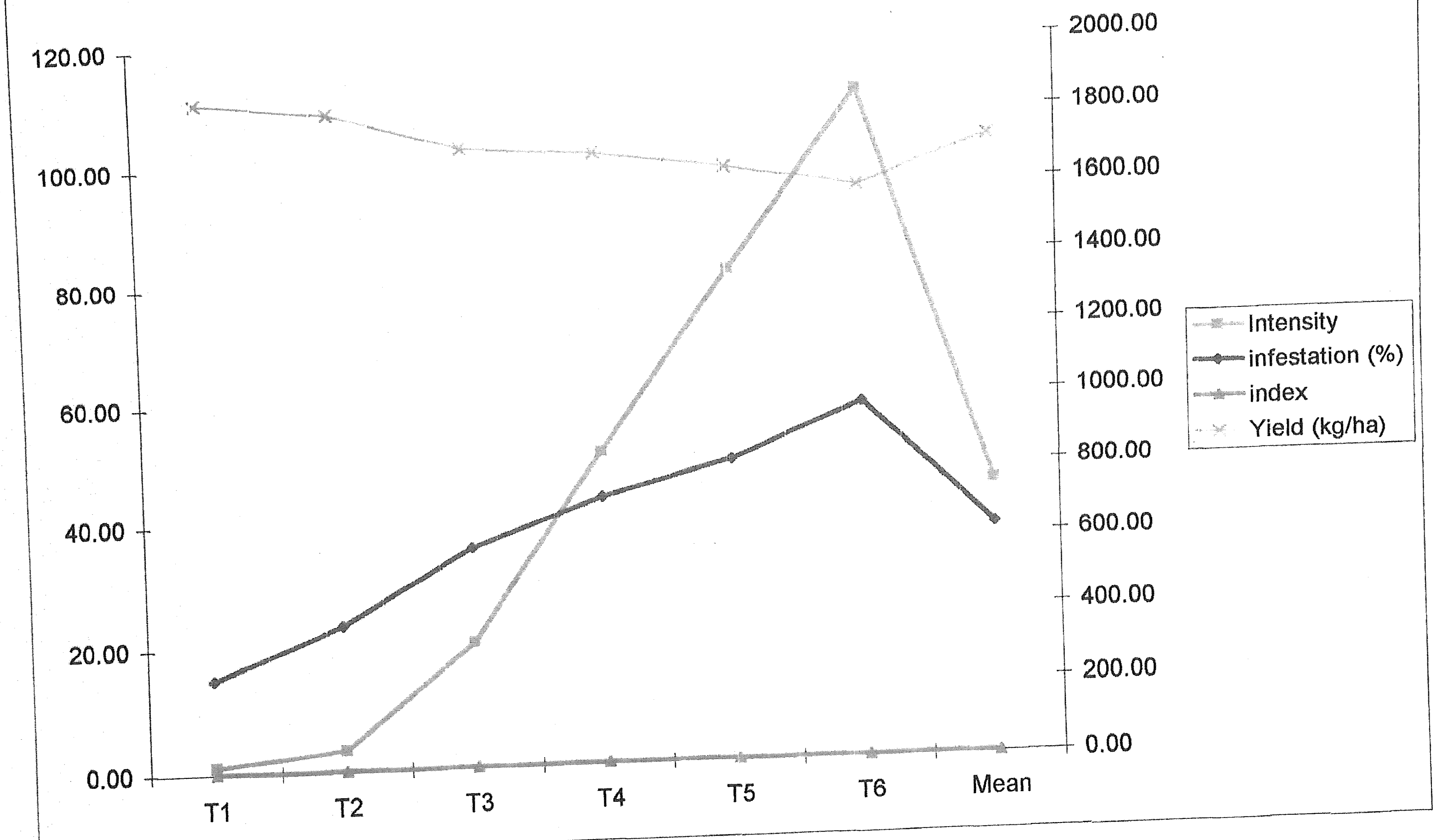
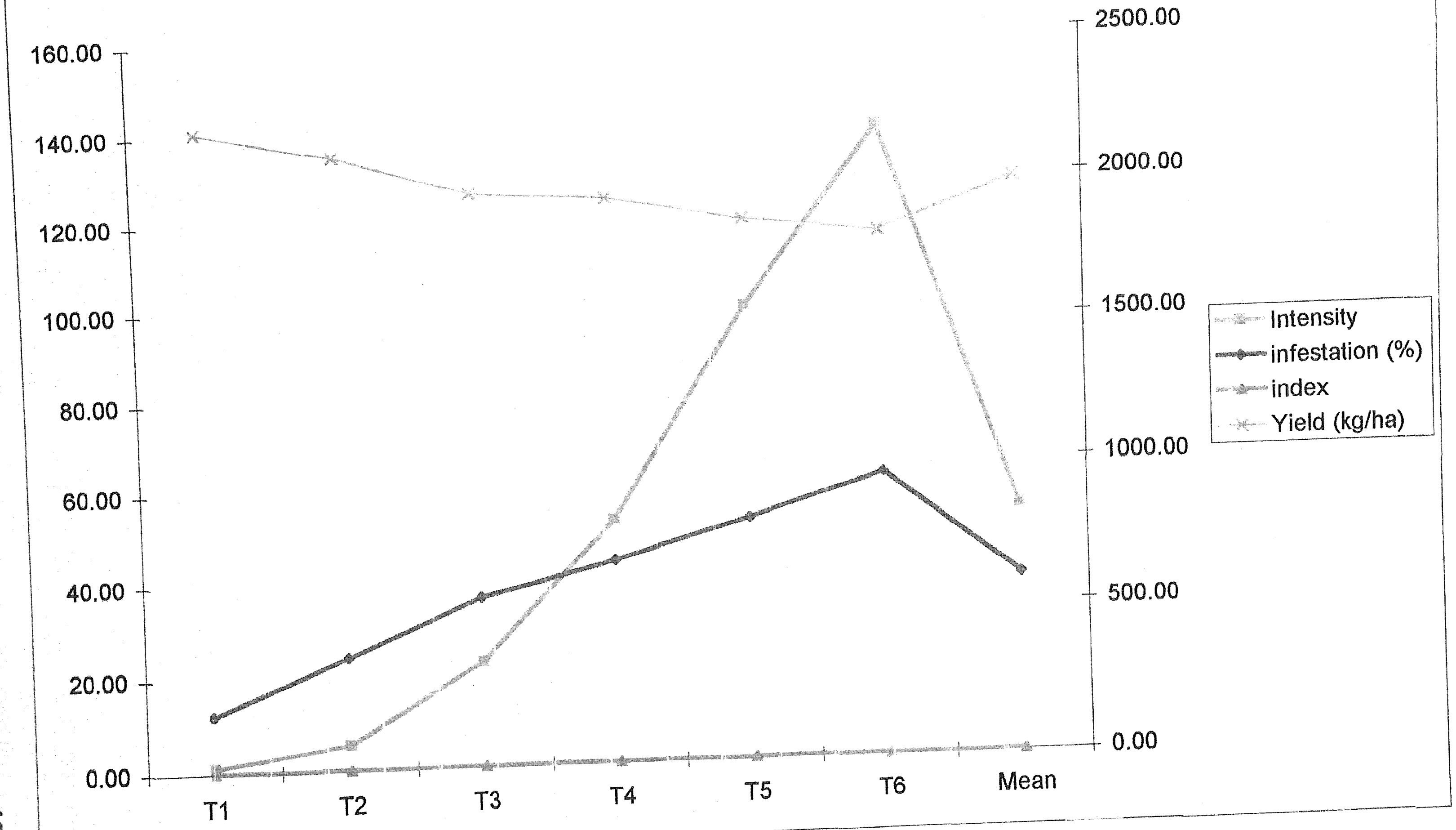


Fig 62. Effect of insecticidal treatments on intensity,infestation, index and yield on aphid population on Varuna during 2004.



treatments were computerized with the yield of the crop to determine the economic injury level (Fig 57 to 62). The data on the population dynamics of the aphids depending upon its intensity were computerized to find out regression equation with the age of the crop to evaluate between aphid intensity with infestation and infestation idices were taken into consideration for calculation the economic threshold level of aphid infestation and its indices variety wise. The extent of losses were calculated form the data of the yield obtained in completely unprotected plots and that of the plots kept under maximum protection through insecticidal application .

(I) Economic Injury Level :

It is evident from (Table 63, 64, &65) that the economic injury level of the aphid intensity was 28.33 aphids per 10 cm central shoot on Variety Varuna, 28.0 on Rohini and 27.82 on Vardan, though there was slight different in these values during both the years, as these were 27.03 and 29.63 on Varuna, 26.80 and 29.37 on Rohini and 26.60 and 29.03 aphids per plants on Vardan during respective years. This slight variation in economic injury level might due to variation in environmental factors influencing the population fluctuations (Fig. 65, 66, &67).

The aphid infestation was taken as the second parameters for describing the economic injury level the economic injury level was calculated to be 39.76 and 34.05 during respective years with an average 36.91 per cent aphid infestation on variety Varuna, 41.09 and 32.16 with an average of

TABLE - 61

Relationship between aphid intensity,infestation and index with the age of different mustard crop during 2004.

Age of Crop (X)	Intensity (y)		
	Varuna	Rohini	Vardan
66	2.80	3.00	3.00
73	10.33	26.66	31.66
80	1.1.66	133.50	233.33
87	375.00	383.33	271.66
94	403.00	391.66	358.33
101	361.66	250.00	306.66
108	0.00	0.00	0.00
Mean	**179.25**	**169.73**	**172.09**

Regression equation

$Y=-252.82+5.0813X$

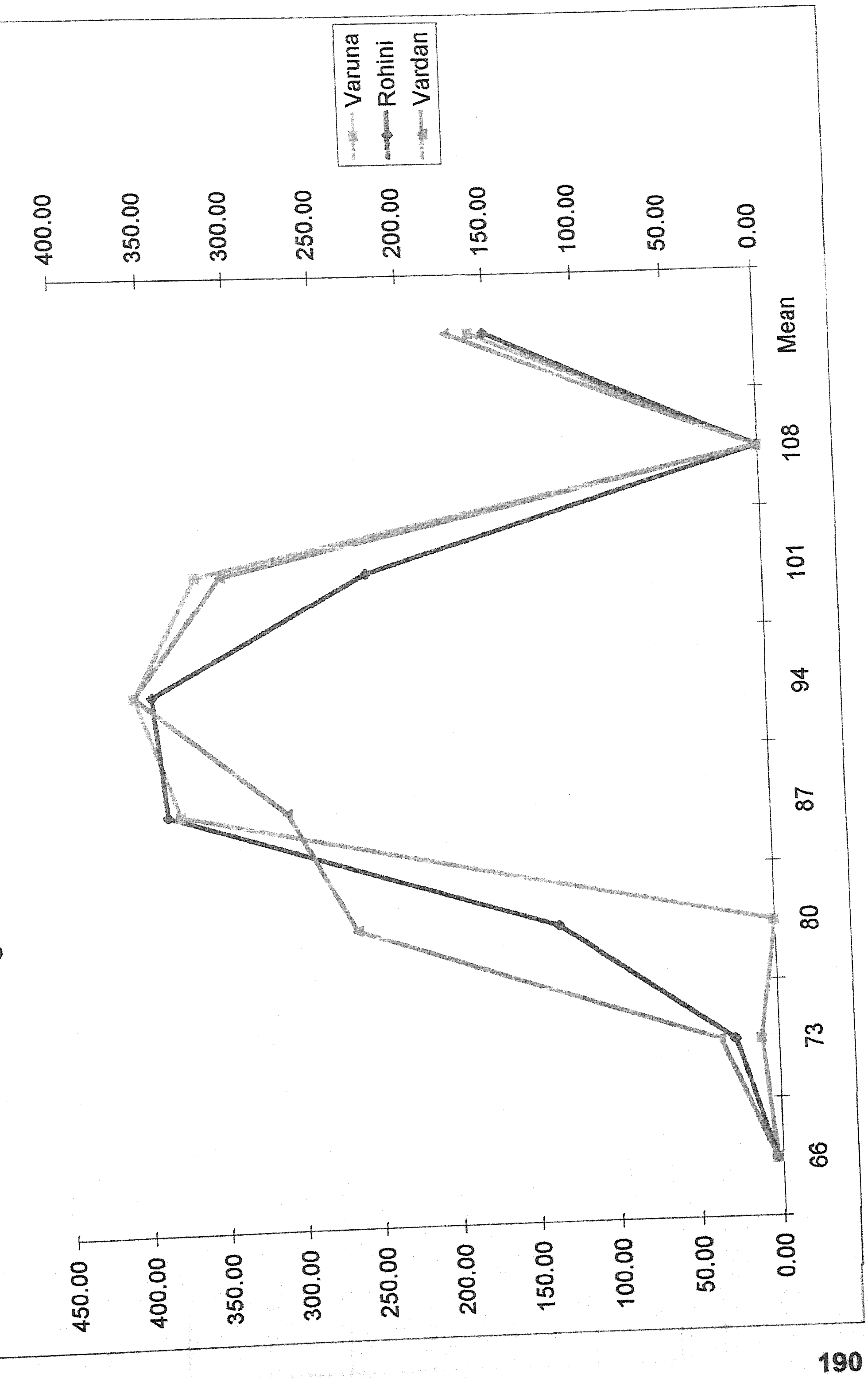


Fig 63. Relationship between aphid intensity,infestation and index with the age of different mustard crop during 2004.

TABLE - 62

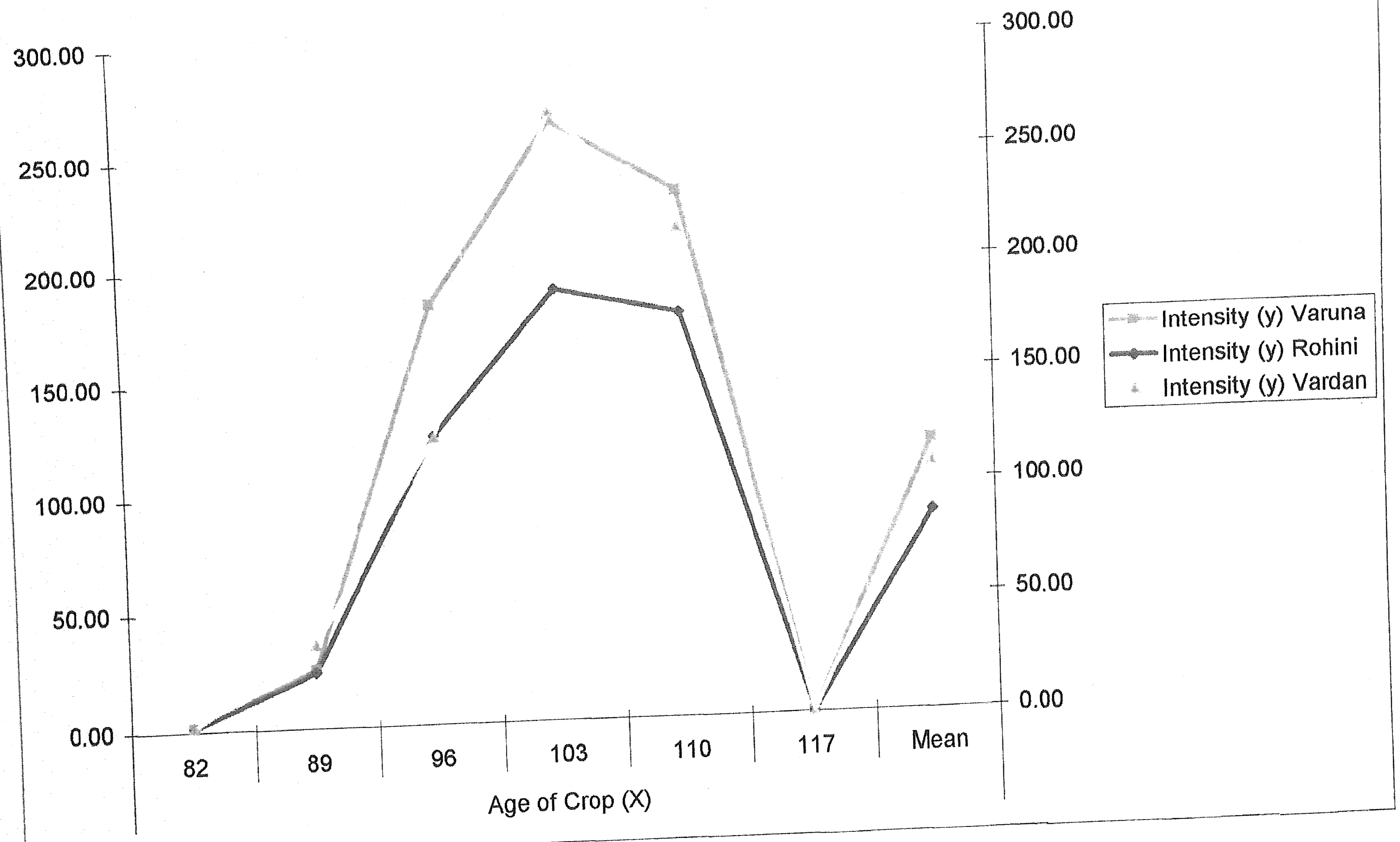
Relationship between aphid intensity,infestation and index with the age of different mustard crops during 2005.

Age of Crop (X)	Intensity (y)		
	Varuna	Rohini	Vardan
82	1.36	1.33	1.40
89	24.66	23.33	35.33
96	183.33	125.00	124.33
103	264.33	188.66	268.33
110	231.66	176.83	215.16
117	0.00	0.00	0.00
Mean	**117.55**	**85.86**	**107.42**

Regression equation

Y=-164.791+3.8376X

Fig.64 Relationship between aphid intensity,infestation and index with the age of different mustard crops during 2005.



36.63 per cent on variety Rohini and 37.97 and 30.73 with an average of 34.35 per cent on variety Vardan showing slightly higher values during Ist year in comparison to second year, ([illegible]).

As the aphid indices are being considered as very common practice for assessing the aphid infestation in the present time, therefore, it has also been considered important for explaining the infestation indices 0.50 and .75 observed as the economic injury level during ist and 2nd year with an average of 0.63 on variety Varuna.

Meanwhile, variety Rohini also responded in the similar fashion showing 0.58 and 0.66 indices with an average of 0.62 and these values were 0.55, 0.64 and 0.60 on variety Vardan, respectively ([illegible]) on the basis of these results economic injury level may be expressed as 28.33, 28.09 and 27.82 aphids on 10 cm central shoot per plant on variety Varuna, Rohini and Vardan, at these levels the aphid infestation will be 36.91, 39.63 and 34.35 per cent along with aphid indices 0.63, 0.62 and 0.60 cm on the respective varieties of mustard.

According to the present investigations, assessment of economic injury levels on the basis of aphid intensity, aphid infestation and indices, is an appropriate idea but aphid intensity and indices were more reliable than infestation of aphid incidence. In contrary to it, Bakhetia and Ghorband (1989) reported that population per plant and per cent of plant infested by *L. erysimi* were equally reliable for estimating aphid incidence. On the other hand, Khurana and Bhatnagar (1991) advocated a sample

TABLE - 63

Economic injury level and economic threshold of aphid on variety Varuna.

Aphid population	Year	Economic injury level	Economic threshold
Aphid intensity	2003 - 2004	27.03	11.57
	2004 - 2005	29.63	19.65
	Average	28.33	15.61
Aphid infestation	2003 - 2004	39.76	36.55
	2004 - 2005	34.05	30.57
	Average	36.91	33.56
Aphid infestation index	2003 - 2004	0.5	0.38
	2004 - 2005	0.75	0.73
	Average	**0.63**	**0.55**

TABLE - 64

Economic injury level and economic threshold of aphid on variety Rohini .

Aphid population	Year	Economic injury level	Economic threshold
Aphid intensity	2003 - 2004	26.8	20.63
	2004 - 2005	29.37	23.54
	Average	28.09	22.08
Aphid infestation	2003 - 2004	41.09	39.35
	2004 - 2005	32.16	30.15
	Average	36.63	34.75
Aphid infestation index	2003 - 2004	0.58	0.52
	2004 - 2005	0.66	0.59
	Average	**0.62**	**0.55**

TABLE - 65

Economic injury level and economic threshold of aphid on variety Vardan.

Aphid population	**Year**	**Economic injury level**	**Economic threshold**
Aphid intensity	2003 - 2004	26.6	15.78
	2004 - 2005	29.03	23.20
	Average	27.82	19.49
Aphid infestation	2003 - 2004	37.97	35.19
	2004 - 2005	30.73	28.96
	Average	34.35	32.07
Aphid infestation index	2003 - 2004	0.55	0.44
	2004 - 2005	0.64	0.59
	Average	**0.6**	**0.51**

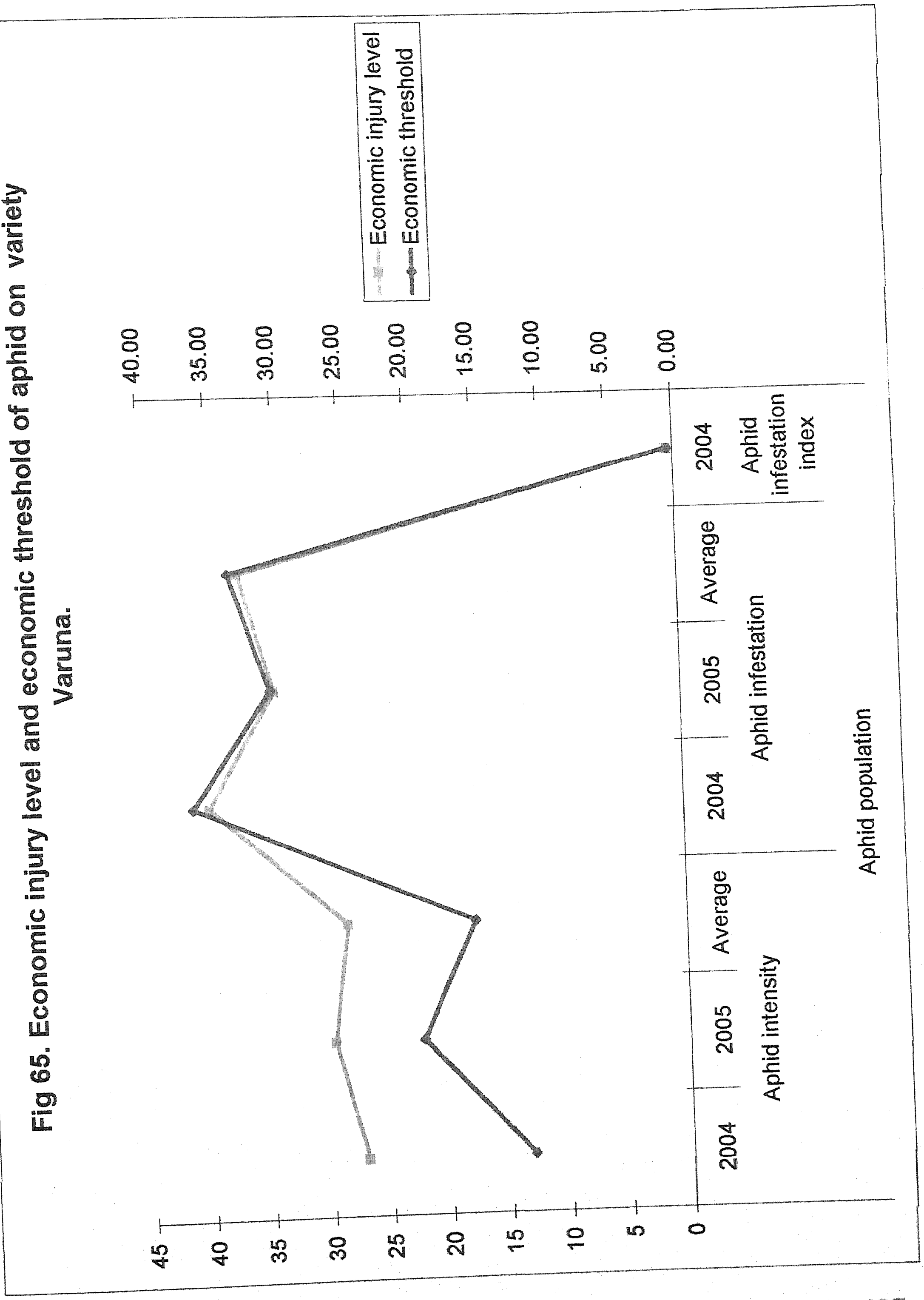


Fig 65. Economic injury level and economic threshold of aphid on variety Varuna.

Fig 66. Economic injury level and economic threshold of aphid on variety Rohini

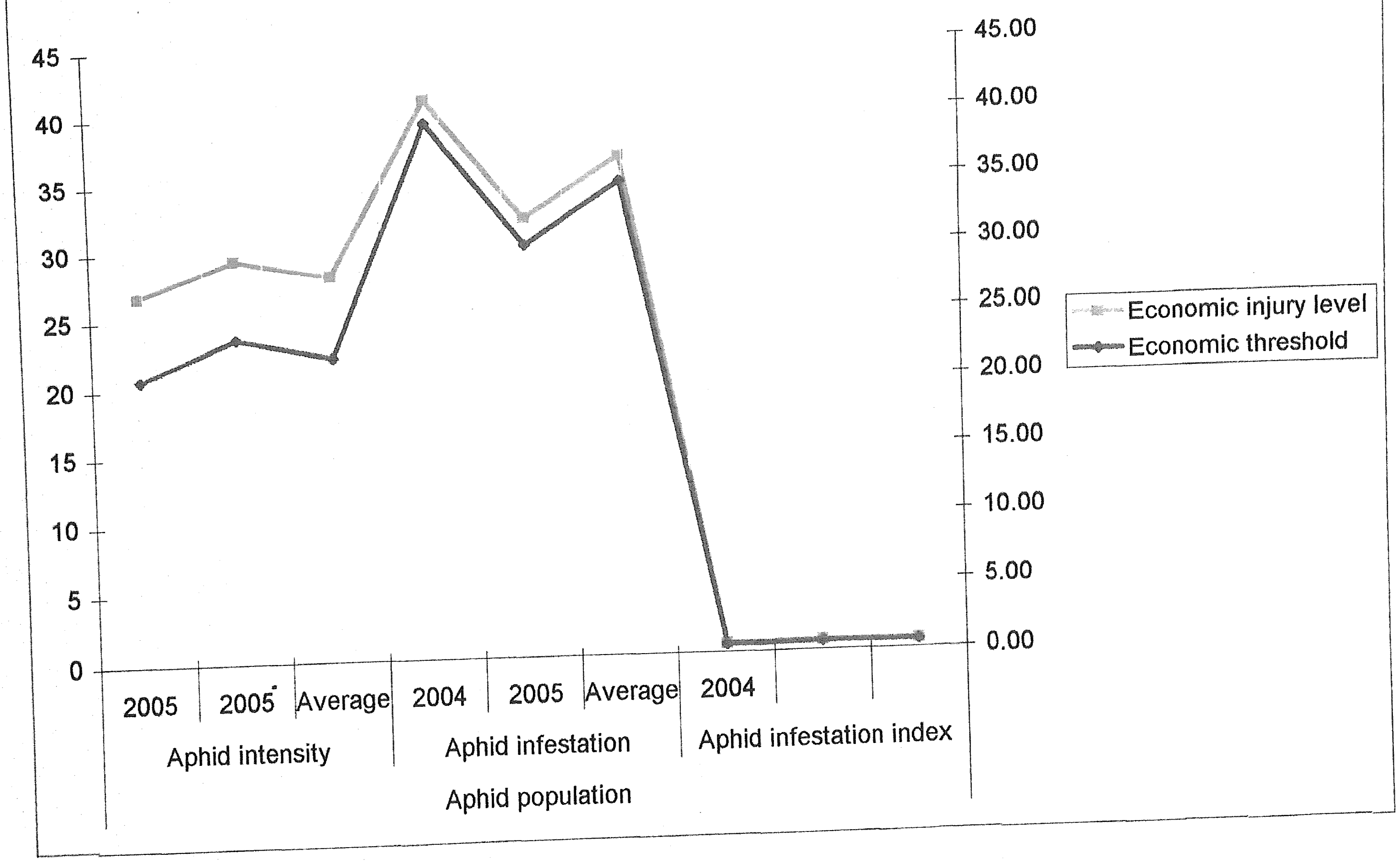
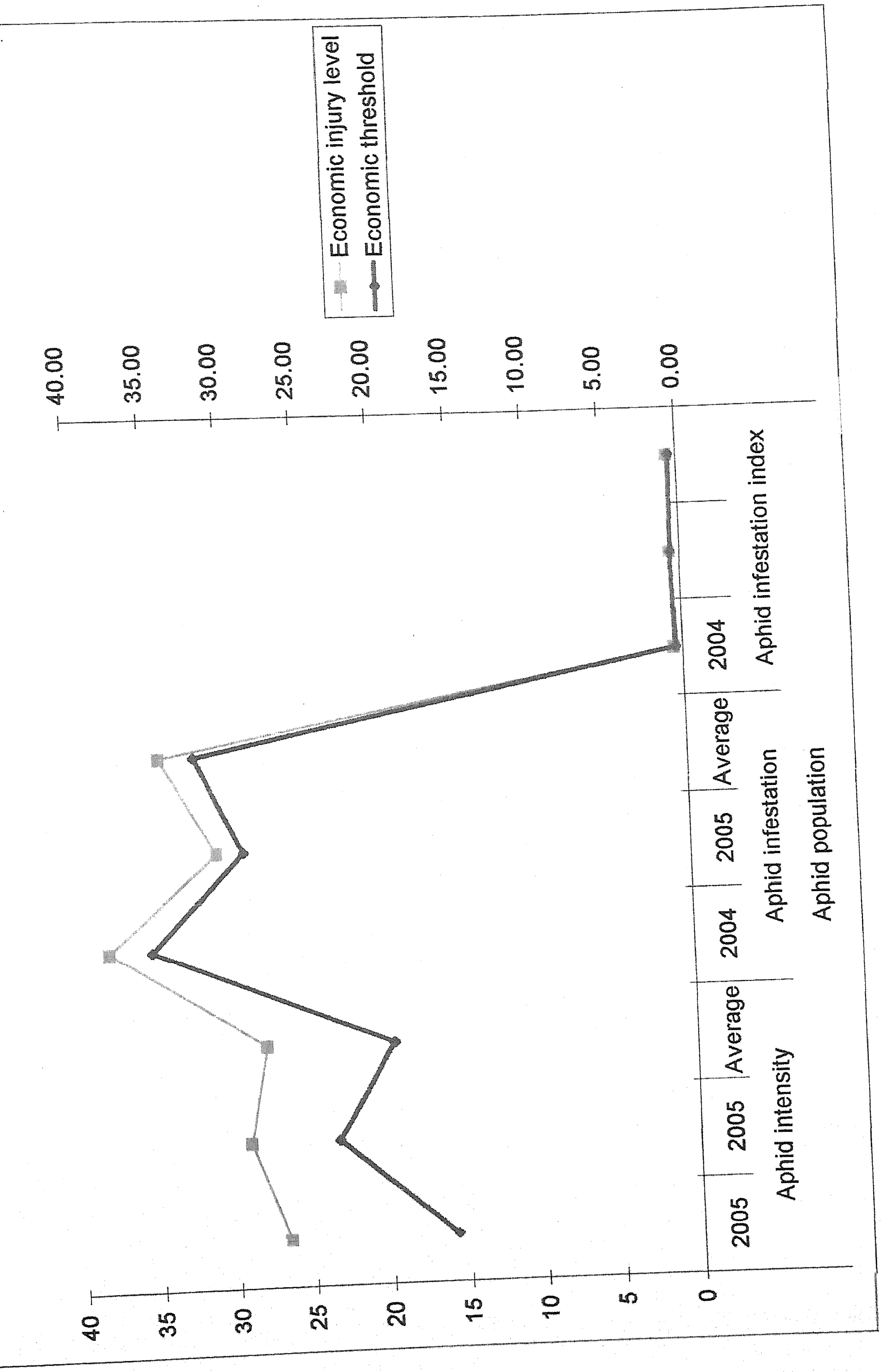


Fig 67. Economic injury level and economic threshold of aphid on variety Vardan



size of 10 central stalk (10 cm long) for estimating the aphid population. Economic injury level was recorded to be 28.33 aphids per plant with its infestation 36.91 per cent and on index of 0.63 on var., Varuna, 28.09 aphids per plant with its infestation 36.63 per cent and index of 0.62 on Rohini and 27.82 per plant with its infestation of 34.35 per cent and index of 0.60 on Vardan. Dutta (1992) also reported EIL as 30 to 40 aphids per 10 cm of the shoot when 17.00 to 28.67 per cent of the plants were infested by aphids on toria.

(III) Economic Threshold :

As the economic threshold is a level from where there are chances of reaching the pest intensity, infestation and indices to the economic injury level within a period of effectiveness of the insecticidal became effective against the aphid population at least in there days after its economic injury level, the economic threshold became effective against the aphid population at least in three days after its treatments (Khurana and Saini, 1970). Three days earlier to economic injury level, the economic threshold of the aphid intensity were determined 11.57 and 19.65 during respective years with an average of 15.61 aphids per plant on variety Varuna, 20.63 and 63.54 with an average of 22.08 on variety Rohini and 15.78 and 23.20 with an average of 19.49 aphids per plant on Vardan, respectively (Table 63, 64, & 65). The threshold of the aphid

infestation was determined as 36.55 per cent during I[st] year and 30.57 per cent during second year with an average value of 36.56 per cent on variety Varuna, 39.35 and 30.15 per cent with an average of 30.07 per cent on Vardan, respectively ([illegible]).

Similar to that of aphid infestation its indices were also calibrated to represent economic threshold by inducing equation thresholds in terms of aphid intensity to its regression equation with infestation index. These were 0.38 and 0.73 with an average of 0.55 cm. on Varuna, 0.52 and 0.53 with an average of 0.55 on Rohini and 0.44 and 0.59 with an average of 0.51 on Vardan.

The economic threshold of aphid intensity was 15.61, 22.06 and 19.49 aphids on 10 cm terminal central shoot per plant when the mustard varieties were having 365.56, 34.75 and 32.07 per cent aphid infestation with its indices of 0.55, 0.55and 0.51 on varities Varuna, Rohini and Vardan, respectively. As regards the aphid intensity at economic threshold level, the present figures are in accordance with those of Singh and Yadav (1998) who have reported this level as aphids per plant at an infestation level of 10 per cent. Bakhetia *et al.* (1979) and Atwal and Singh (1989) suggested economic threshold of *L. erysimi* as high as 50 aphids per shoot. Lee (1988) obtained no reduction in yield when infestation level were 30 per cent on cabbage and mustard leaves. The recent estimates made under all India Coordinated Research Project on

Rapessed- Mustard, the present views are in full support, as ET level of 50 aphids, having 30 per cent infestation was found on B. juncea in Punjab 9-19 (Av. 14) aphids per plant on B. juncea Cv. RH 30 and *B. napus* Cv. GSL-1 (Anon, 1994).

(Iv) Extent of Losses:

The population of mustard aphid was not much prominent during 2003-2004 and 2004-2005, however. The extent of losses were quite distinct on all the three varieties being 38.80 per cent on Vardan during the ist year and 31.00, 26.40 and 40.00 per cent on respective varieties during the second year (Table 66). The average losses may be explained as 38.15 per cent in Varuna, 35.25 per cent in Rohini and 19.40 per cent in Vardan irrespective of the years. Very specific observations were also recorded on extent of losses caused by a single increase in aphid population were 1.689-1.882 kg/ha yield of Varuna 1.70-2.15 kg/ha of Rohini and 2.08-2.49 kg/ha of Vardan during respective years on the basis of regression coefficient between aphid intensity and yield of the different varieties. The oil content of the produce were reduced by 2.29 per cent in Rohini and 1.45 per cent in Vardan due to non adoption of protection technology (Table 66 fig. 68, 69 & 70)

The extent of losses upto 38.15 per cent in Vardan, 35.25 per cent in Rohini and 39.40 per cent in Vardan are equal to those recorded as 34.68 per cent at Bhatilnda (Anon 1995 b) and 30.46 per cent at Hisar (Anon 1996) on different strains of *Brassica jancea*. The earlier reports

from Kanpur also indicate 37.66 per cent losses in Varuna and 33.33 per cent of Krishna (Anon, 1994). On the other hand, these losses may be as high as 87.9 per cent in Delhi and 91.3 per cent in Punjab (vir et. al. 1980) The per unit increase in aphid population causing 1.68-1.88 Kg. loss in Varuna. 1.70-215 Kg in Rohini and 2.08-2.49 Kg. on Vardan may be argued on the basis of earlier reports of Atwal and Singh (1969) as they noticed that every increase of one aphid per plant tented to decrease in seed yield by 1.5 Kg./ha. The losses in oil content may be insecticides.

7. EVALUATION OF TIME OF APPLICATION OF INSECTICIDES:

The time of application of the most popular insecticide phosphamidon was calibrated by changing patterns of sprayings (After Fifteen days) and by determining their impact on aphid intensity and indices on the most commercial variety Varuna only.

The perusal of Table 67 indicate that the aphid intensity was ranging from 2.65-8.47 an infestation index of 0.44 to 0.75 during the ist week of January was considered, as the appropriate time for starting the insecticidal treatments, at this time aphid population was merely reaching indicating the exact time for the treatment. A single spraying of phoshamidon 85 SL @ 0.03 per cent provided good protection to the crop only upto 15 days and thereafter, the aphid intensity and aphid intensity and aphid infestation indices had cross the economic injury level for a few days with the GEP 32.24 aphids per plant at an index of 1.85. Meanwhile, its repetitions after 15 days was quite effective in keeping down the pest

TABLE - 66

Extent of losses due to mustard aphid *L.erysimi* on different varieties of mustard

Year	Varuna		Rohini		Vardan	
	Grain Production	Oil Production	Grain Production	Oil Production	Grain Production	Oil Production
2003 - 2004	45.3	2.37	43.90	2.04	38.8	1.32
2004 - 2005	31	2.20	26.69	1.70	40	1.60
Average	38.15	2.29	35.25	1.87	39.4	1.46

Fig 68. Extent of losses due to mustard aphid *L.erysimi* on variety Varuna.

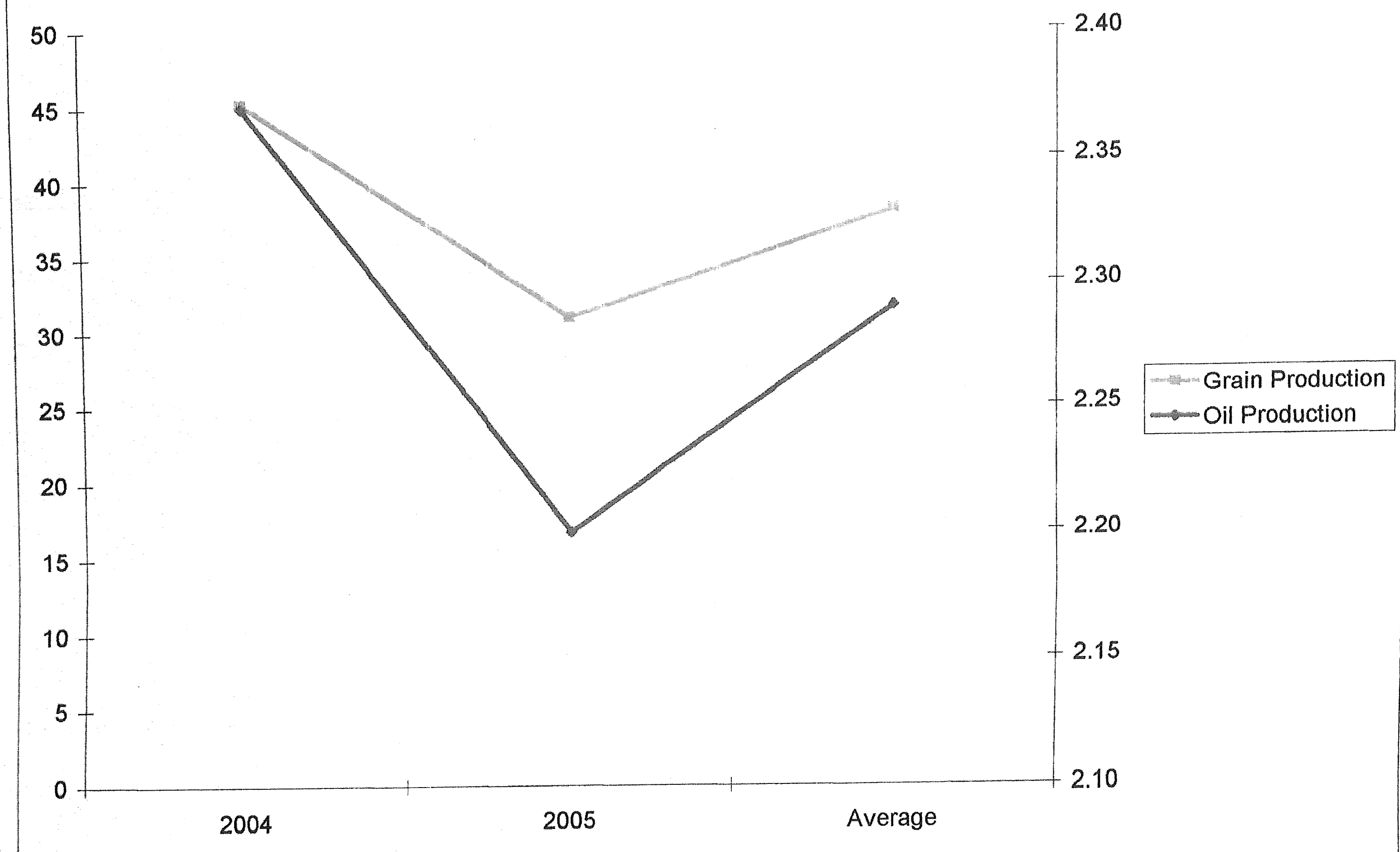


Fig 69. Extent of losses due to mustard aphid *L.erysimi* on variety Rohini.

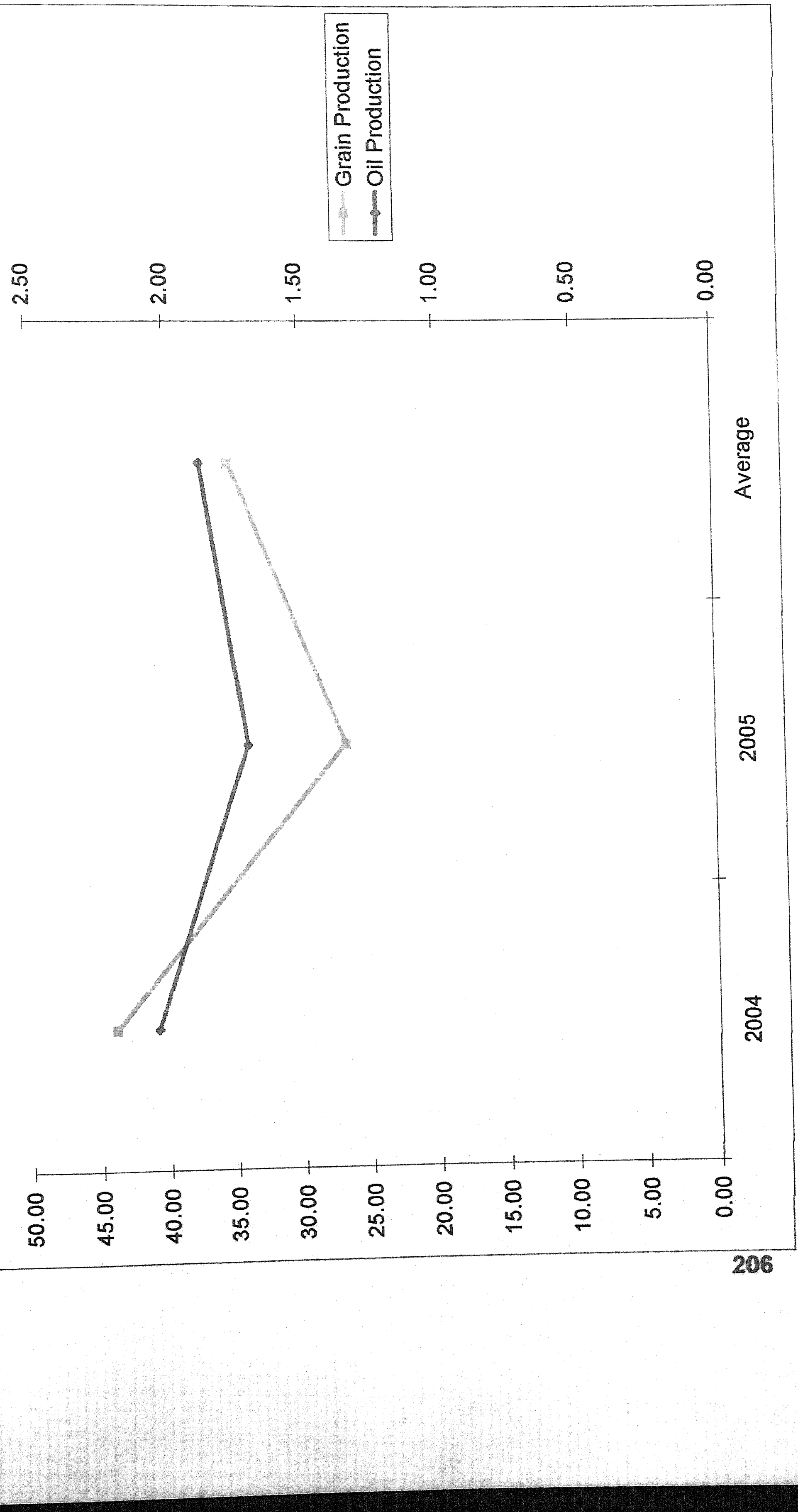
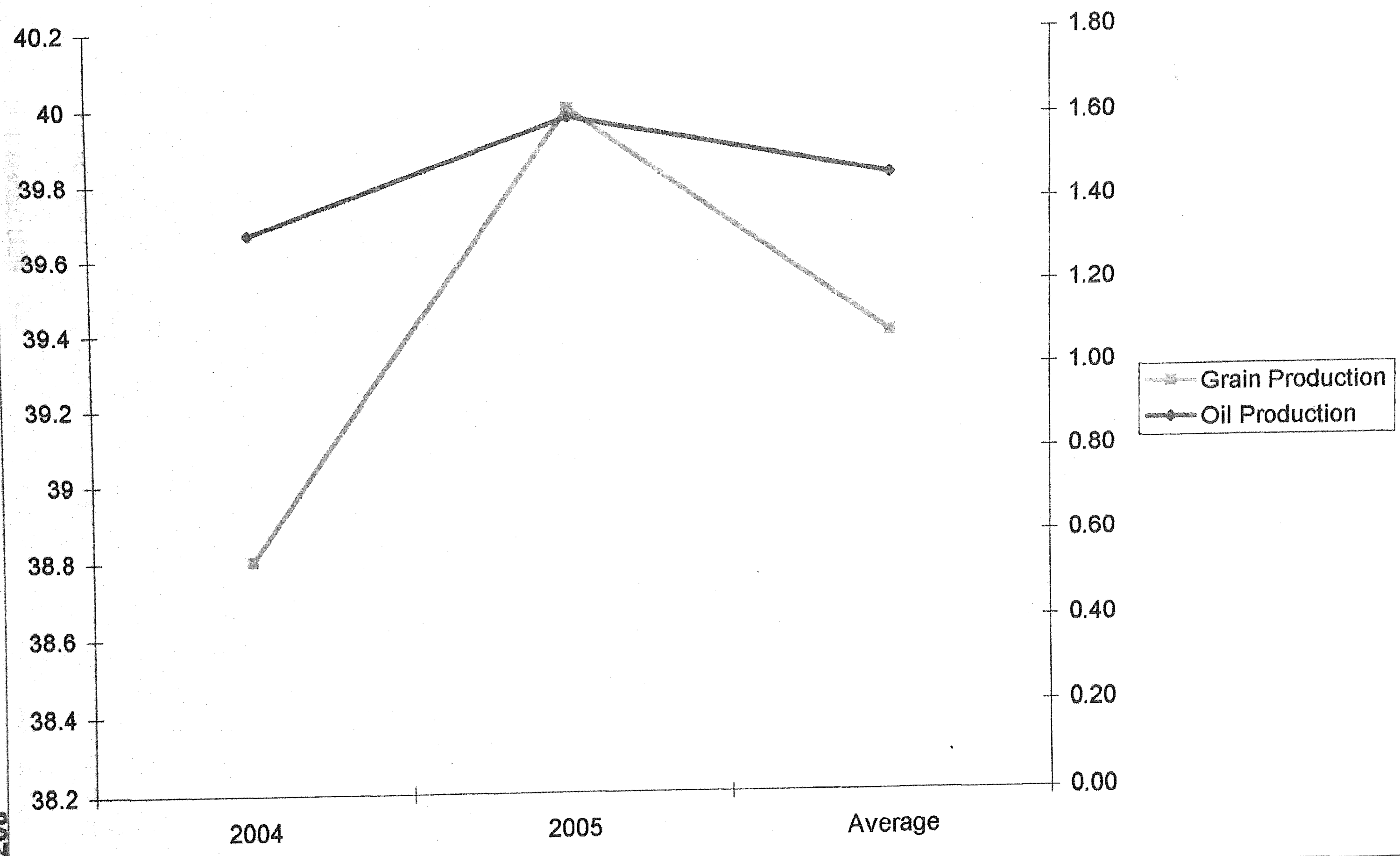


Fig 70. Extent of losses due to mustard aphid *L.erysimi* on variety Vardan.



population below economic injury level with GED 13.05 and the 3rd and 4th time provided much more reduction in the aphid population and infestation indices. On the other hand, deletion of only Ist or second applications were quite effective in keeping down the GEP below economic injury level but another deletion of the third and fourth insecticidal application were unable to check the pest infestation (fig. 71&72).

The economic analysis of this data indicated that a single application of phosphamidon 85 SL @ 0.03 per cent provided maximum benefit cost ratio of 25.83 with a net return Rs. 9426.50 / ha, though the maximum return Rs. 11159.00/ha was obtained by early 2 and 3 applications of phosphamidon, respectively. The deletion of only Ist spraying had reduced the production to a great extent and only a return of Rs. 5869.37 was obtained with a benefit cost ratio 5.36 while futher deletion of 2nd and 3rd earlier sprays had reduced the net return to Rs. 5043.75 and Rs. 3325.62 with the benefit cost ratios of 6.91 and 9.11 respectively (Table 68, & 69 fig 73, 74 & 75)

The benefits of insecticidal applications at economic threshold levels had also been advocated by Singh and Yadav (1988) Bath *et. al.* (1989) who suggested threshold management of *L. erysimi* by insecticidal application at economic threshold level on mustard and radish crops respectively. The application of phosphamidon 85 SL (0.03 per cent) at the economic threshold level is also based upon the basic philosophy of judicious use of insecticides (Metcalf and Luckmann; 1975) while the

TABLE - 67

Effect of insecticidal treatments on aphid population of *L. erysimi* on mustard

Treatment	Aphid Population									GEP
	5-Jan	12-Jan	19-Jan	26-Jan	2-Feb	9-Feb	16-Feb	23-Feb	3-Mar	
	Aphid intensity(Aphids/plant)									
T_1	4.93 (2.22)	5.29 (2.30)	14.29 (3.78)	15.84 (3.98)	24.10 (4.90)	49.28 (7.02)	87.61 (9.36)	64.80 (8.05)	24.11 (4.90)	32.24
T_2	3.72 (1.93)	2.72 (1.65)	7.07 (2.66)	13.32 (3.65)	14.67 (3.83)	13.54 (3.68)	30.58 (5.53)	20.16 (4.49)	11.63 (3.41)	13.05
T_3	2.72 (1.65)	2.95 (1.72)	7.29 (2.70)	9.06 (3.01)	12.82 (3.58)	11.09 (3.33)	23.72 (4.87)	15.37 (3.92)	6.76 (2.60)	10.20
T_4	2.65 (1.63)	3.13 (1.77)	4.45 (2.11)	3.31 (1.81)	9.24 (3.04)	13.25 (3.64)	27.77 (5.27)	10.05 (3.17)	3.50 (1.87)	9.59
T_5	4.16 (2.04)	20.43 (4.52)	23.62 (4.86)	4.62 (2.15)	22.37 (4.73)	13.76 (3.71)	31.02 (5.57)	8.02 (2.87)	3.80 (1.95)	14.67
T_6	7.40 (2.72)	20.97 (4.58)	28.51 (5.34)	51.12 (7.15)	78.67 (8.87)	14.59 (3.82)	37.82 (6.15)	10.18 (3.19)	5.24 (2.29)	28.28
T_7	8.47 (2.91)	19.01 (4.36)	30.25 (5.50)	53.14 (7.29)	82.63 (9.09)	109.62 (10.47)	166.41 (12.90)	16.48 (4.06)	9380.00 (3.13	55.09
T_8	5.57 (2.36)	22.47 (4.74)	26.32 (5.13)	65.29 (8.08)	96.24 (9.81)	124.54 (11.16)	182.52 (13.51)	114.27 (10.69)	35.04 (5.92)	74.69
CD 1%	**0.57**	**0.27**	**0.61**	**0.80**	**0.66**	**0.64**	**0.77**	**0.36**	**0.76**	

NB: Figure in parentheses are $\sqrt{x}$ transformed values
GEP - General equilibrium position.

TABLE - 68

Effect of insecticidal treatments on aphid index of *L. erysimi* on mustard

Treatment	Aphid Population									GEP
	5-Jan	12-Jan	19-Jan	26-Jan	2-Feb	9-Feb	16-Feb	23-Feb	3-Mar	
	Aphid intensity(Aphids/plant)									
T_1	0.75 (0.86)	0.60 (0.77)	1.06 (1.03)	1.66 (1.29)	1.75 (1.32)	1.93 (1.39)	2.22 (1.49)	3.11 (1.76)	3.62 (1.90)	1.85
T_2	0.56 (0.75)	0.50 (0.71)	0.86 (0.93)	0.78 (0.88)	1.66 (1.29)	1.40 (1.18)	1.81 (1.35)	2.42 (1.55)	2.53 (1.59)	1.39
T_3	0.50 (0.71)	0.42 (0.65)	0.84 (0.92)	0.71 (0.84)	1.19 (1.09)	1.19 (1.09)	1.57 (1.25)	2.29 (1.51)	2.29 (1.51)	1.22
T_4	0.50 (0.71)	0.60 (0.77)	0.56 (0.75)	0.54 (0.73)	1.06 (1.03)	1.16 (1.08)	1.63 (1.28)	1.93 (1.39)	1.96 (1.40)	1.17
T_5	0.52 (0.52)	0.40 (1.18)	1.60 (1.26)	0.56 (0.75)	1.63 (1.27)	1.60 (1.26)	1.84 (1.35)	1.96 (1.40)	2.06 (1.43)	1.16
T_6	0.62 (0.79)	1.43 (1.20)	1.78 (1.33)	1.90 (1.38)	2.09 (1.44)	1.93 (1.39)	1.93 (1.39)	2.22 (1.49)	2.03 (1.42)	1.77
T_7	0.44 (0.66)	1.43 (1.20)	1.69 (1.30)	1.93 (1.39)	2.32 (1.52)	2.53 (1.59)	3.26 (1.80)	3.50 (1.87)	3.46 (1.86)	2.29
T_8	0.69 (0.09)	1.69 (0.14)	1.90 (0.13)	2.09 (0.13)	2.67 (0.20)	2.96 (0.20)	3.66 (0.12)	4.08 (0.13)	4.47 (0.14)	2.69
CD 1%	**0.09**	**0.14**	**0.13**	**0.13**	**0.20**	**0.20**	**0.12**	**0.13**	**0.14**	

NB: Figure in parentheses are $\sqrt{x}$ transformed values

GEP - General equilibrium position.

TABLE - 69

Economical analysis of insectidal treatments on mustard

Treatment	Cost of treatment (Rs/ha)	Economical return				Benefit cost ratio
		Yield (Kg/ha)	Yield increased over control (Kg/ha)	Cost of increased Yield (Kg/ha)	Net return (kg/ha)	
T_1	365	1476.18	783.32	9791.50	9427	25.83
T_2	730	1488.09	795.23	9940.37	9210	12.62
T_3	1095	1607.13	914.27	11428.37	10333	9.44
T_4	1460	1702.38	1009.52	12619.00	11159	7.64
T_5	1095	1250.01	557.15	6964.37	5869	5.36
T_6	730	1154.76	461.90	5773.75	5044	6.91
T_7	365	988.11	295.25	3690.62	3326	9.11
T_8	-	692.86	-	-	-	-
CD (5%)		**289.82**				

Fig 71. Effect of insecticidal treatments on aphid index of *L. erysimi* on mustard

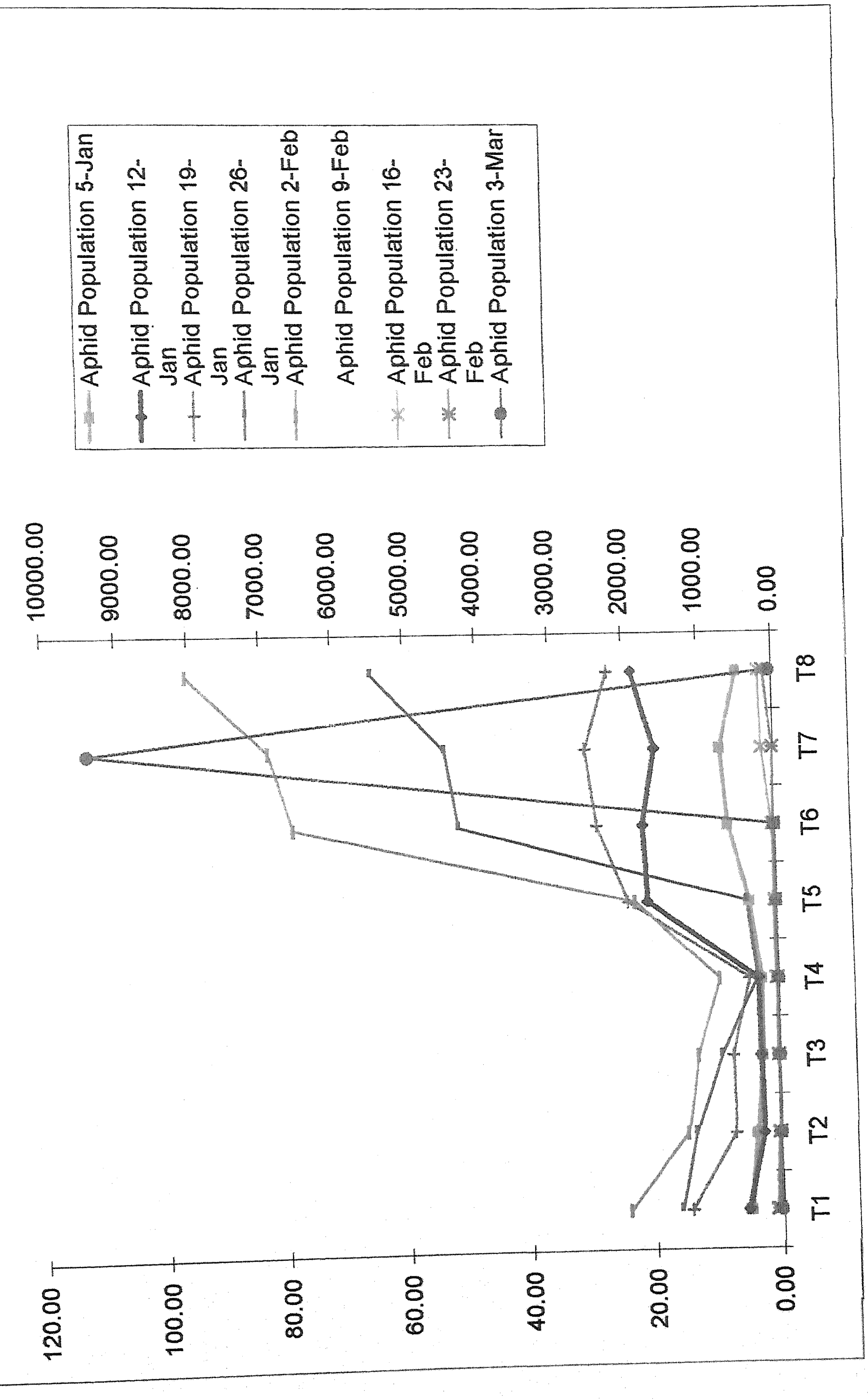


Fig 72. Effect of insecticidal treatments on aphid index of *L. erysimi* on mustard

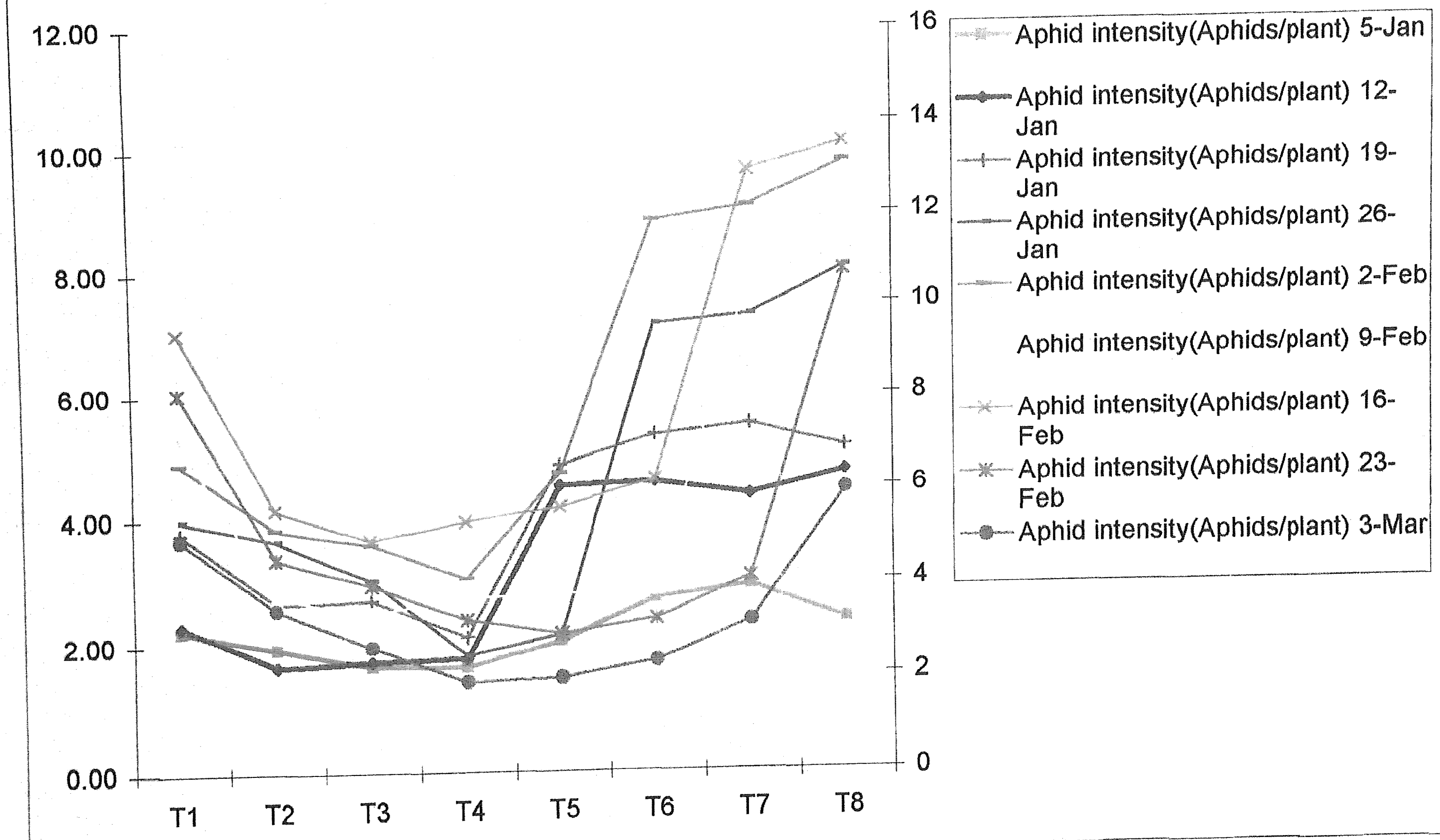


Fig 73. Effect of insecticidal treatments on aphid index of *L. erysimi* on mustard

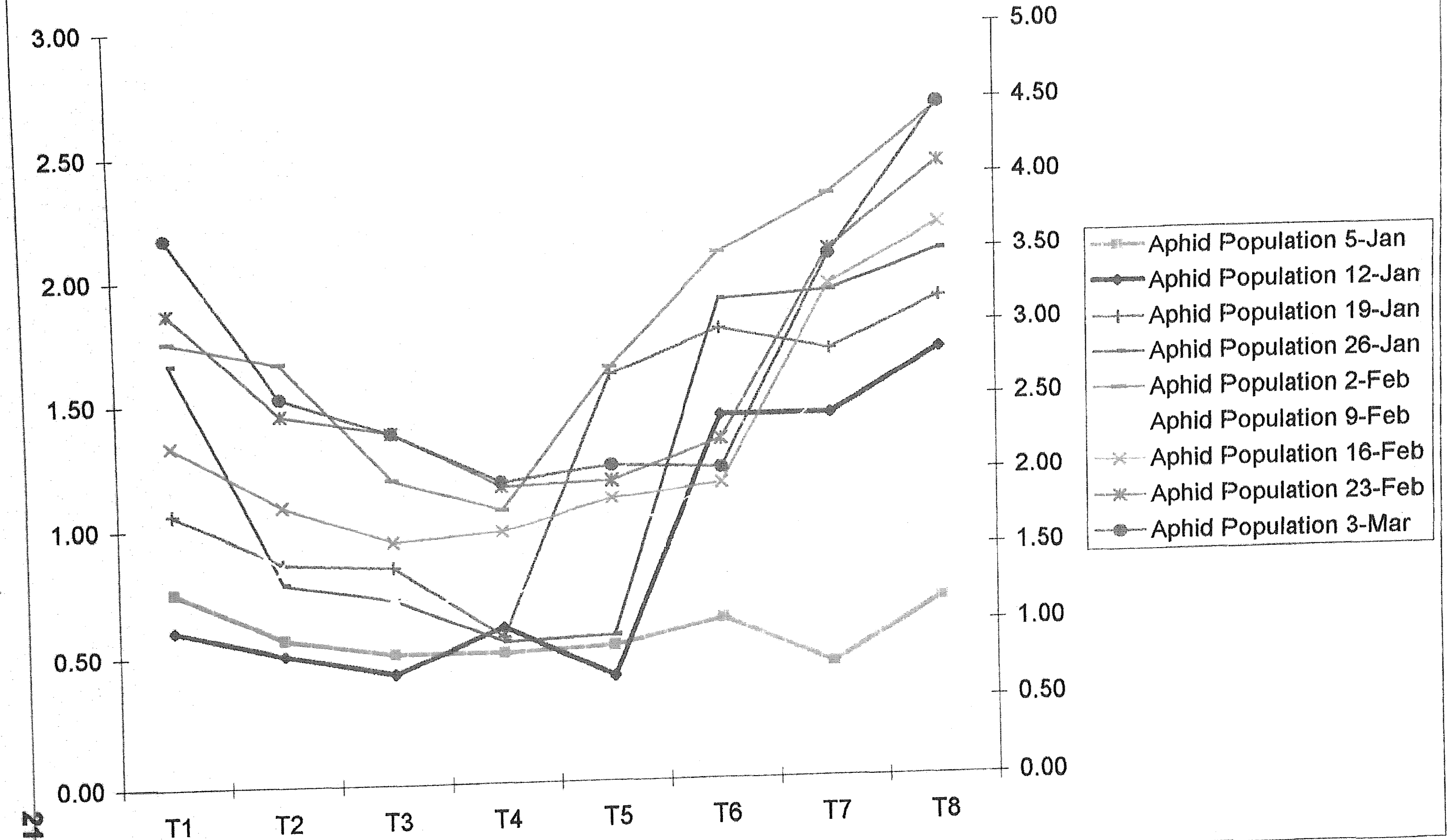
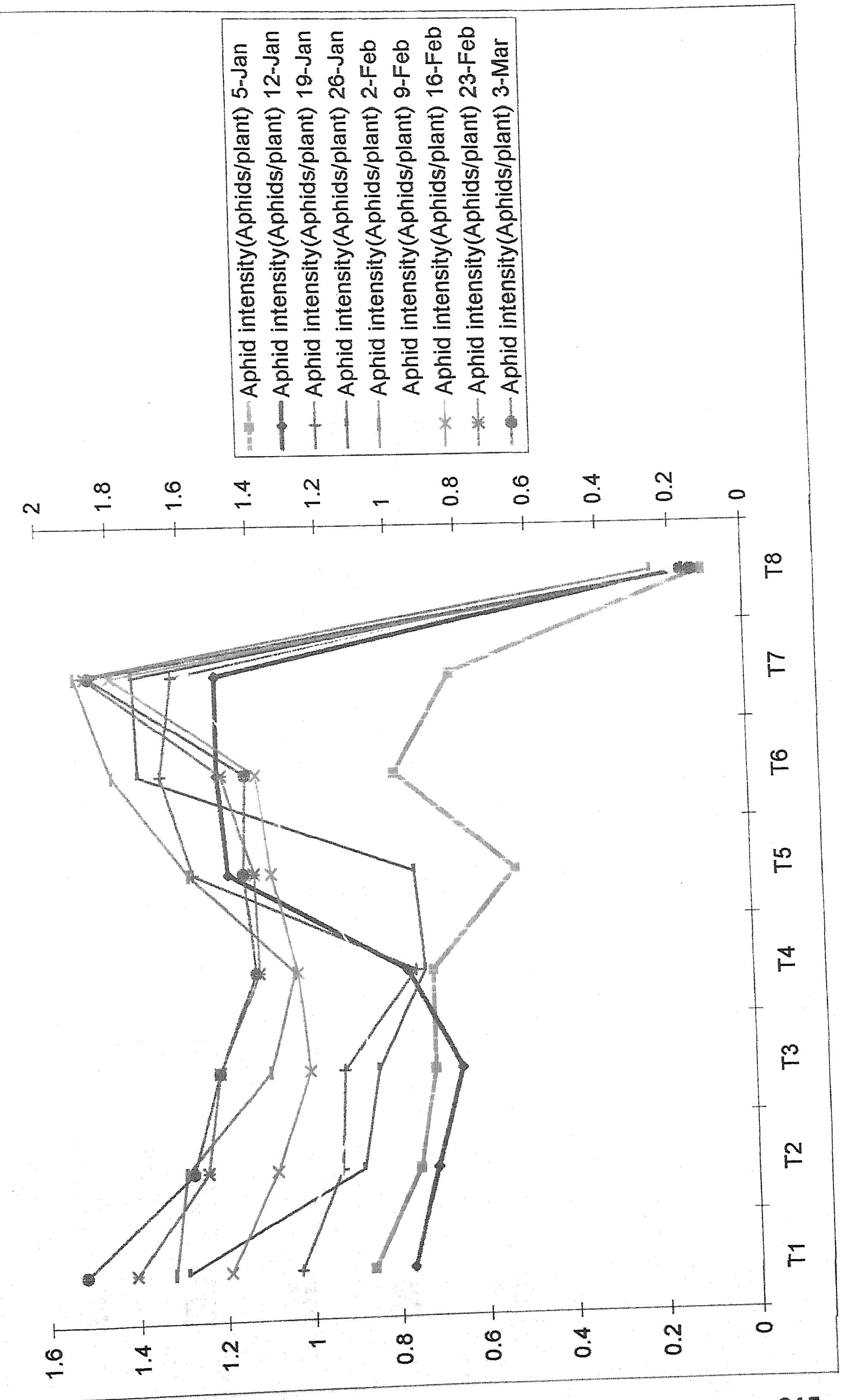


Fig 74. Effect of insecticidal treatments on aphid index of *L. erysimi* on mustard



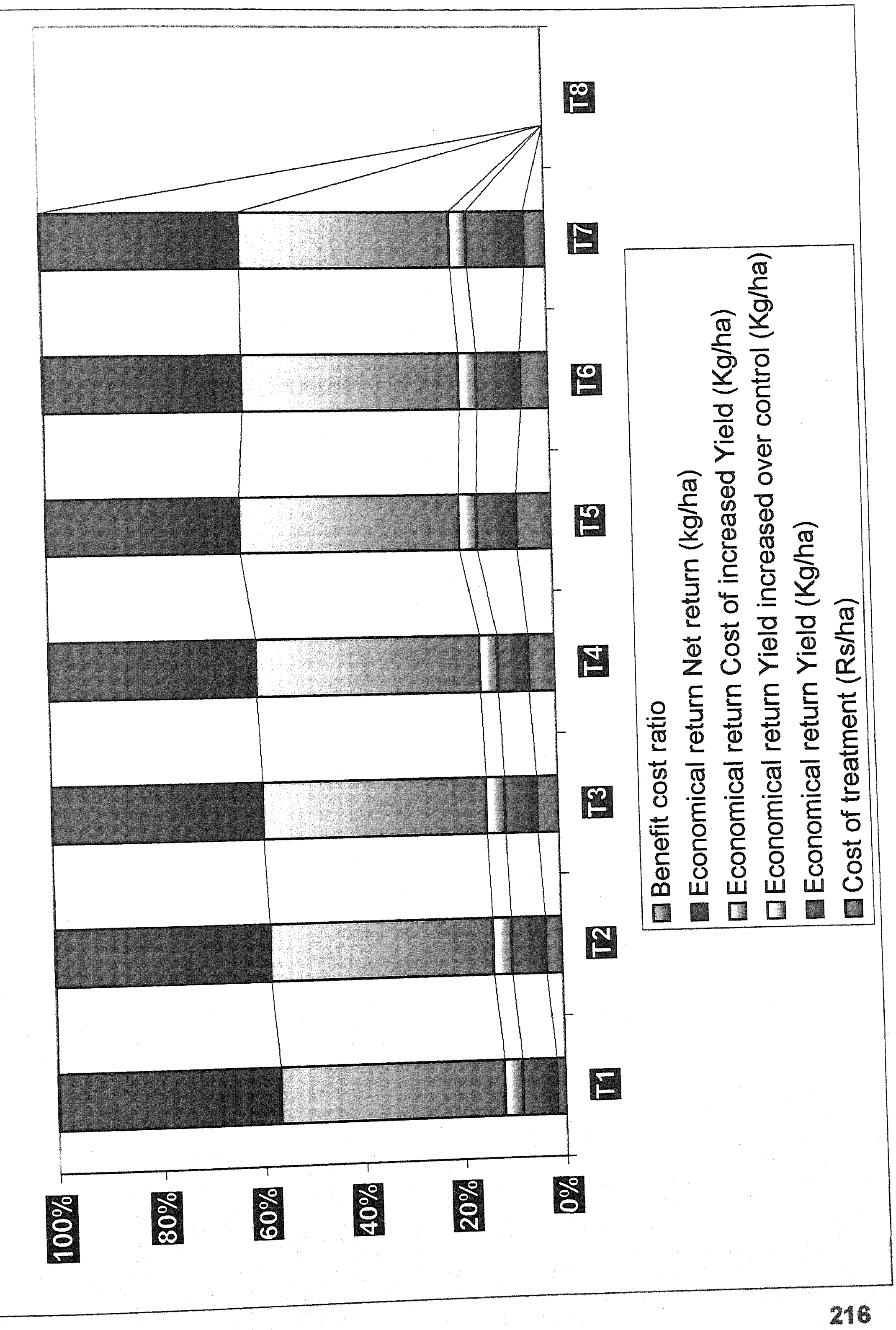
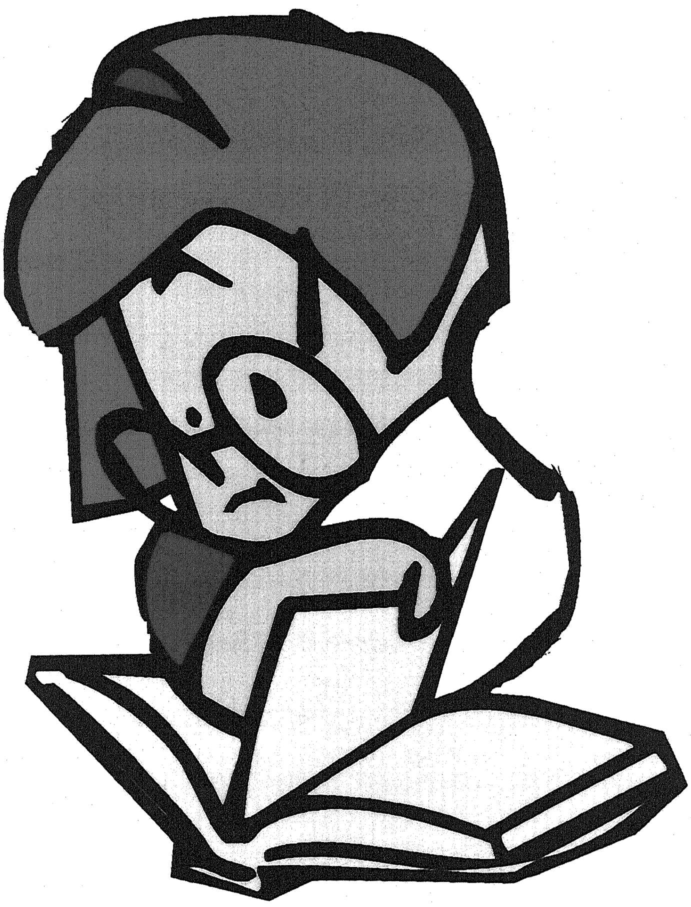


Fig. 75 Economical analysis of insectidal treatments on mustard

maximum benefit cost ratio obtained by single earlier application of phosphamidon may be confirmed by earlier views of Singh (1969) obtained maximum returns by two sprays of oxydemeton methyl on mustard crop.

It clearly indicate that insecticidal treatment at the economic threshold level are more useful and only two sprays can down the GEP of the aphid population below economic injury and their deletion may be highly unfruitful for the production of mustard.



SUMMARY

CHAPTER - FIVE

SUMMARY

The investigations on the ecological studies related to distribution population dynamics and assessment of economics injury level of *Lipaphis erysimi* Kaltenbach (Aphididae: Homoptera) were conducted on three most popular varieties viz., Varuna, Rohini and Vardan of mustard, *Brassica juncea* (L.) Czern. & Coss, were conducted at Research Farm and at the Insectory of the department of Zoology, D.V.College, Orai during 2003 - 04, to 2004 - 05. The crop was raised under normal agronomical practices and kept under constant observations for recording the population fluctuations in relation to biotic and abiotic factors of the environment to prepare the forecasting models. The assessment of economic losses in yield and oil content were estimated by creating varying insecticidal pressures through repeated weekly application of phosphamidon to determine the economic injury level, economic threshold and extent of losses, simultaneously. The time for making judicious and economical application of the insecticides was

determined consequently for effective management of this severe pest. The salient features of the results are being summarized under here:

(1) The aphid appeared with its intensity level of 1.33 - 2.80 aphids per plant having 40.00 - 53.33 per cent infestation and 0.43 - 0.60 indices on var. Varuna , 1.33 - 3.00 aphid per plant with infestation 53.33 - 63.33 per cent per plant and its indices 0.46 - 0.60 on Rohini and 1.40 - 3.00 aphid per plant with an infestation 43.33 - 60.66 per plant and its indices 0.40 - 0.60 on Vardan, during the third week of January irrespective of the years when maximum temperature was 20 ^{O}C and relative humidity was more than 90 per cent and low evaporation rate of mm per day.

(2) The peak intensity of 264.33 - 403.00 aphids per plant on Varuna , 388.66 - 391.66 on Rohini and 268.33 - 358.33 on Vardan irrespective of the years was recorded in the Ist fortnight of February when aphid infestation was ranging 90 - 96 per cent in the I st year and 56 to 96 per cent during 2nd year with an indices of 1.83 - 3.16 on Varuna , 1.83 - 3.16 on Rohini and 1.83 - 3.00 on Vardan, When temperature was ranging 22 -27 ^{O}C maximum and 9.4 -11.97 ^{O}C minimum and relative humidity 60.50 - 70.42 per cent.

(3) The population of the aphid was eliminated from the field in the last week of February and Ist week of March during respective years. The aphid prevailed upto the age of 101 -110 days in case of all the varieties. The temperature not exceeding 24.42 ^{O}C maximum and 10.28 ^{O}C minimum along with relative humidity 66.5 and 48.2 per cent in morning and evening hours with wind speed 3.9 km/hr during Ist year and 20 °C maximum and 12.00 °C minimum with 70 per cent relative humidity and 2.88 km /hr wind speed during the preceding week become inconducive for its multiplication and responsible for its migration from the crop.

(4)The Coccinellied species including *Coccinella septempunctata* Linn. *C. repanda* Thunberg, and *Chilomenes (Menochilus) sexmaculata.* Fabr. appeared after second week of February when the crops of all the varieties were 101 days old. In the beginning, the population of adults was more than its grubs but in the beginning of March 10 to 20 grubs per plant were recorded against 2 to 5 adults. The predators are very effective in reducing the aphid population but they did not appear in the peak activity period.

(5) Aphid intensity was found to increase at faster rate in the beginning being 0.40, 1.08, 13.05 and 39.05 aphids per day on

Varuna against 0.42, 4.09, 28.81 and 5.47 aphids per day on Vardan and 0.42, 3.38, 15.28 and 35.69 aphid per plant per day on Rohini in 3rd , 4th and 5th week of January and Ist week of February during Ist year, and 0.19, 3.33, 22.66 on Varuna;0.19, 3.14, 14.52 on Rohini and 0.20 , 4.84 and 12.71 aphids per plant per day on Vardan during 3rd ,4th and 5th week of January and reduced thereafter. The trend of aphid infestation and indices were also on the same pattern.

(6) The development of pest forecasting model requires prolonged infestation of the pest species on the crop and in case of shorter duration of pest invasion the development of forecasting model is bit difficult.

(7) The aphid intensity was found to determine by 19.78 per cent by temperature on var.Vardan, 9.81 per cent on Varuna and 6.02 per cent on Rohini. The relative humidity was observed to regulate the pest upto the extent of 64.45, 62.19 and 51.29 per cent on these varieties but wind speed could show only 7.23 per cent role in case of var. Rohini

(8) The role of temperature on aphid infestation did not exceed 5 per cent and only relative humidity contributed upto 90.54

per cent in case of Varuna 85.98 per cent in case of Vardan and 84.33 per cent in Rohini and wind speed responded upto the extent of 3.51 per cent in case of var.Vardan.

(9) The responses of temperature was 5.94, 12.14, and11.54 per cent on Varuna, Rohini and Vardan ,while 61.85, 74.90 and 72.66 per cent role of relative humidity was noticed on the respective varieties and wind speed could not be considered important factor for making any forecasting on the basis of pest infestation indices on the basis of the Ist year observation.

(10) In the second year temperature governed 18.13 ,19.43 and 16.89 per cent aphid intensity , while relative humidity played 28.23 ,26.96 and 30.86 per cent role in determining aphid intensity on Varuna ,Rohini and Vardan varieties, respectively.

(11) The aphid infestation was determined upto 7.72, 11.77 and 8.44 per cent by temperature and relative humidity controlled 3.58, 37.15 and 34.84 per cent, while wind speed contributed 30.36, 30.06 and 26.88 per cent infestation var.Varuna, Rohini and Vardan, respectively.

(12) The role of humidity (evening) was 56.25, 48.70 and 52.96 per cent on aphid indices against 7.90, 16.64 and 13.89 per cent role of wind speed on Varuna , Rohini and Vardan, respectively.

(13) The mean aphid intensity was slightly higher 181.74 on Vardan followed by 180.00 on Varuna and 156.01 on 10 cm central shoot per plant on Rohini. While its infestation was 72.08, 67.90 and 77.02 with indices 1.87, 1.76 and 1.94 on these varieties. The plant characteristics like height, branches, test weight, oil content and germination were found to be improved by insecticidal treatment.

(14) Maximum protection in aphid population has enhanced the plant height from 1.65 to 1.81 m in Varuna, 1.83 to 1.97m in Rohini and 1.40 to 1.49 m in Vardan.

(15) Branching was increased from 3.16 to 5.33 in Varuna, 3.33 to 5.00 in Rohini and 4.63 to 6.66 m in Vardan varieties, due to complete protection from aphids.

(16) Test seed weight was increased from 5.50 to 6.60 g in Varuna, 4.60 to 5.53 g in Rohini and 2.83 to 4.60 g in Vardan due to insecticidal treatments irrespective of the years.

(17) Oil content was increased due to insecticidal treatment from 36.50 to 40.10 per cent in Varuna, 40.46 to 42.50 per cent in Rohini and 39.90 to 41.41 per cent in Vardan, irrespective of the years.

(18) Germination was increased from 90.66 - 99.33 per cent in Varuna, 91.00 to 100 per cent in Rohini and 92.33 to 100 per cent in Vardan, irrespective of the years after complete protection from the aphids by the insecticidal treatments.

(19) The economic injury level was determined as 28.33, 28.09 and 27.82 aphids on 10 cm central shoots per plant on Varuna, Rohini and Vardan, respectively. In term of infestation, this level may be explained as 36.91, 36.63 and 34.35 per cent, while its indices were 0.63, 0.62 and 0.60 on the respective varieties. The aphid intensity per plant and aphid indices were found to be more reliable parameters for expressing the aphid incidence while its infestation was not much stable, because of its rapid increase in comparison to earlier ones.

(20) Economic threshold of aphid intensity was 15.61, 22.08 and 19.49 aphids on 10 cm terminal central shoot per plant on var.Varuna, Rohini and Vardan, along with 36.56,34.75 and 32.07 per cent

aphid infestation and 0.55, 0.55 and 0.51 its indices on respective varieties.

(21) The extent of losses in yield were determined as 18.15 per cent in Varuna, 35.25 per cent in Rohini and 39.40 per cent on Vardan.

(22) A single aphid was found to be responsible to causes 1.689 - 1.882 kg loss in yield of Varuna,1.70-2.15 kg in Rohini and 2.08 -2.49 kg /ha in Vardan during both the years.

(23) Oil content of the produce were reduced by 2.29 per cent in Varuna, 1.87 per cent in Rohini and 1.45 per cent in Vardan due to non - adoption of protection technology.

(24) Need based timely application of insecticidal treatments, was determined as the most important components for keeping down pest population below economic injury level.

(25) The insecticidal application in the beginning before reaching the aphid population at economic threshold level but showing aphid infestation indices at the ET level was effective to keep

down the pest population for about 3 weeks and repetition of the same treatment a fortnight later was quite effective in keeping down the GEP below economic injury level . Neigther further repeation of the treatment nor its deletion was found advisable for suppression of pest population. The deletion of these treatments was not effective to keep down the GEP below economic injury level.

(26) The benefit cost ratio was maximum 25.83 for single timely application of insecticides at ET level and its repetition 15 days later provided benefit cost ratio 12.62, through maximum return was obtained by applying phosphamidon 85 SL @ 0.03 per cent four times but that had given a very poor benefit cost ratio of 7.64 .The deletion of only earlier one or two application had provided minimum return.

Thus, these findings provided a basic infrastructure for application of integrated pest management programmes on most popular mustard *B.juncea* var.Varuna, Rohini and Vardan, being raised in Orai,Jalaun district under sole and mixed cropping.

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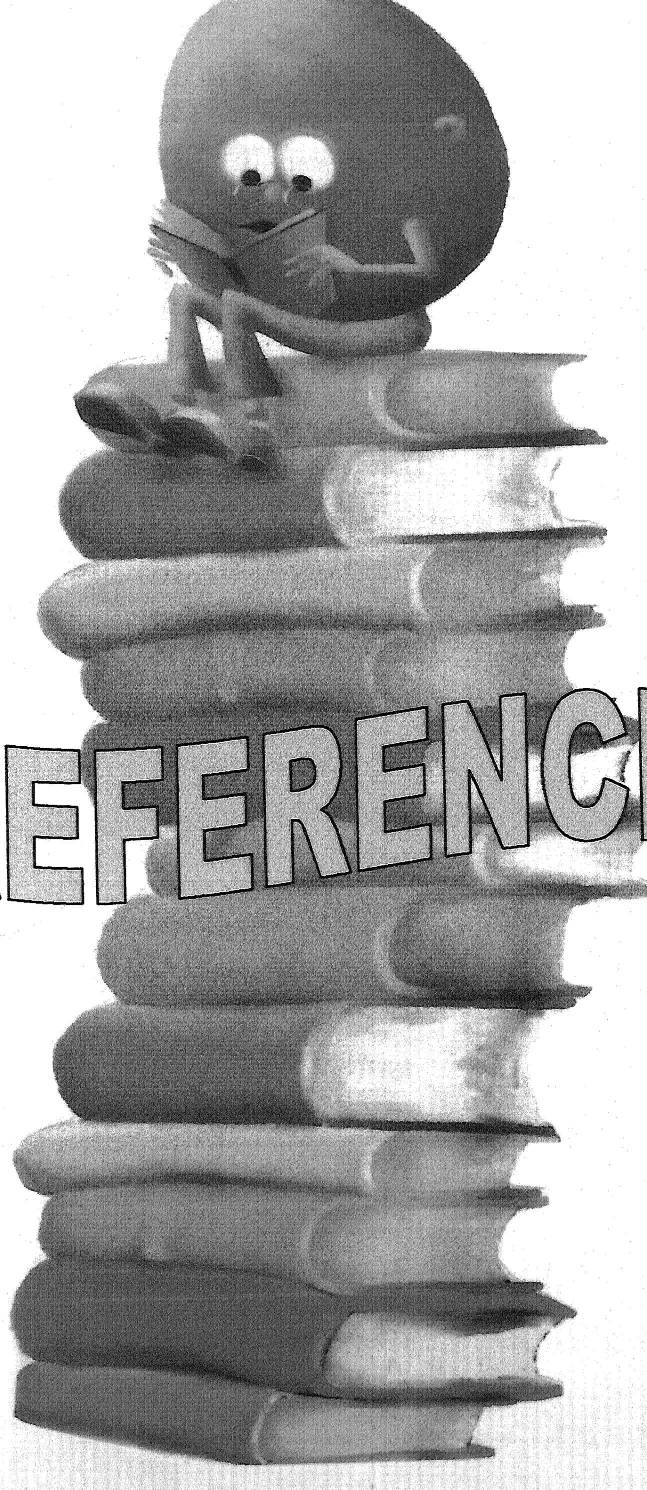

CHAPTER -SIX

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